This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

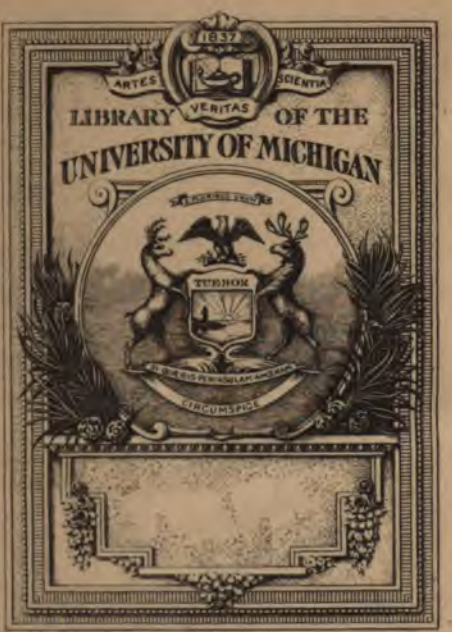
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

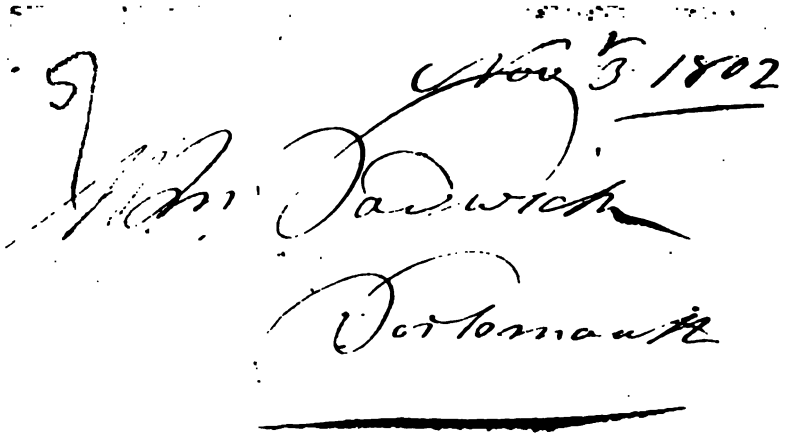
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`


1837
ARTES
VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR
CIRCUMSPICE

WH
553
W74
1761

Wilson's Anatomy



Navigation New Modelled:

OR, A

TREATISE

OF

Geometrical, Trigonometrical, Arithmetical, Inſtrumental, and *Practical*

NAVIGATION;

TEACHING

How to keep a *Reckoning*, both in *Latitude* and *Longitude*, without TABLES or INSTRUMENTS, by a NEW METHOD never yet Publiſhed: Illuſtrated with Practical Examples of keeping a JOURNAL, and correcting it by an *Obſervation*; with a New Way of finding the *Variation*, and Time of *High-Water* at any known Port.

TOGETHER WITH

All Neceſſary TABLES, calculated to the New STILE, and the Projection of the Sphere *Orthographick* and *Stereographick*. Alſo Current Sailing, with other Pleaſant Queſtions, and how to Correct the *Longitude* by a Solar Obſervation.

The EIGHTH EDITION, with the Addition of *Spherical Trigonometry*, and *Aſtronomy*.

By HENRY WILSON.

LONDON:

Printed for W. and J. MOUNT, T. PAGE and SON on *Tower-Hill*, M.DCC.LXI.

To the Right Honourable

PATTEE,

Lord Viscount

TORRINGTON.

My Lord,

I SHOULD have been at a Loſs to approach your Lordſhip *with this DEDICATION, if I had not firſt had the Honour immediately to Serve your Honourable Father Admiral* Byng, *in the Quality of* Mathematician, *aboard of His Majeſty's Ship the* Barfluer, *in the* Mediterranean; *I at*

the ſame Time having the Honour to attend and aſſiſt your Lordſhip in your Mathematical Studies Aboard of the ſaid Ship, and his Lordſhip after his return to England, *being pleaſed to Accept and Approve of a Dedication of this Book of Navigation: I humbly crave Leave to do myſelf the additional Honour, to make an humble Offering of the fifth Impreſſion to the Patronage of your Lordſhip, and to continue it under the ſame Noble Family and Title, where it has been ſo much encouraged, and beg Leave to be allowed the Honour to ſubſcribe myſelf,*

My Lord,

Your Lordſhip's moſt humble,

And moſt obedient Servant,

HENRY WILSON.

Nathaniel Bowditch
Essex
Salem
1773

THE

EPISTLE

TO THE

READER.

COURTEOUS READER,

THE general Approbation that this Book has meet with, both in the Navy and amongſt Merchant Ships, hath encouraged the Bookſeller, not only to print a large Number, but alſo to be at the Charge of the Addition of *Spherical Trigonometry*, *Aſtronomy*, &c. and engraving all the Cuts upon Copper-Plates, with

ſuch other Improvements, as might be thought neceſſary to make it a *Compleat Treatiſe of Navigation.* But if there are yet ſome in the World, that not being capable of Improvements themſelves, envy what is made by others: Let ſuch conſider, that there is room enough for every induſtrious Navigator, to employ his Talent that Way: Nor is it poſſible to conclude, that Navigation is arrived at its *ne plus ultra*, ſo long as the Longitude remains to be ſuch a puzzling Subject to our beſt Mathematicians, eſpecially now, in a Day when the Parliament had been pleaſed to offer ſuch a liberal and plentiful Gratuity to him that ſhall firſt diſcover it: For the ſupplying of which Want of an exact Method to find the Longitude, I have, toward the latter End of this Treatiſe, inſerted a very uſeful Method for finding the Longitude by the Sun, any Day at Noon, when the Sun can be ſeen. But to wave this Subject, we find that Mathematical Studies did hitherto, and do yet admit of Improvement: For in former Times, when Mathematical Sciences were in their Non-Age, and *Minerva*'s Fruit did not grow in ſo many *Engliſh* Gardens as it doth now, it was thought (and indeed was) an extraordinary Attainment in Trigonometrical Operations, when the Antients found out the Way of applying Right Lines to Arches of Circles, which we call Sines, Tangents, and Secants, and could thereby perform their Trigonometrical Calculations, although with the vaſt Trouble of multiplying by 5, 6, 7, or 8 Figures, which took up a large Quantity both of Time and Room; but this Manner of Operation was much facilitated by my Lord *Napier's* admirable Invention of Logarithms, with the Improvement of Mr. *Henry Brigg's*; the Uſe of which is now ſo common, that he would be thought but a

ſlender

ſlender Mathematician, that knows no other Way of Operation than by Multiplication and Diviſion, the Trouble whereof is now thought intolerable: To this we may add the Invention of *Gunter*'s Scale, both long and ſliding, upon which, with a Turn of a Pair of Compaſſes on the one, or only removing the other, are performed thoſe Propoſitions in *Trigonometry* which formerly required Abundance of Figures in the Operation; but all this not being thought ſufficiently expeditious at Sea, there have been alſo invented Tables ready calculated, called Traverſe Tables, or Tables of Difference of Latitude and Departure, wherein by Inſpection only you may anſwer any Queſtion in any of the ſix Caſes of *Plane Sailing*, and alſo find the Difference of Longitude, as is taught at large in this Treatiſe: But of all the Improvements that have been made, I never heard of any that ever attained to a Method for ſolving all the Caſes in *Trigonometry*, and *Practical Navigation*, *viz.* the keeping of a Reckoning both in Latitude and Longitude, with ſufficient Exactneſs, without any Tables, Books or Inſtruments, or any other Help, but only Pen and Ink, or a Piece of Chalk; and this is what I have preſented to the World in this Treatiſe, and which I take for granted was never Taught nor Printed before, excepting that Proportion by which I have wrought the ſix Caſes of *Plane Sailing* by the *New Method*, which we find hinted at by *Snellius*, in his *Cyclometria*, quoted by Mr. *Collins*, in his Book entitled, *The Plane Scale New Plained*, *&c.* in the Title Page of which Book he enumerates amongſt the reſt of the Contents, [*Arithmetical Navigation, or Navigation performed by the Pen, if Tables were wanting*, *&c.*] at the firſt Sight of which I thought my Deſign had been anticipated, till looking further

into the Book where he is upon that Subject, (*viz.* in Page 118 of the firſt Book) I find he touches upon no more but only that Caſe, where three Sides of a right-angled Triangle are given (or found) to find an Angle; but (in Page 120) ſpeaking of that Caſe of one Side, and two Angles given, to find the other Side, he ingeniouſly owns, that it cannot be done without a Table of Sines, and that is what I have laid down in this Treatiſe, *viz.* The Solution of all the other five Caſes of *Plane Sailing*, or any other Operation that depends upon a right-angled plane Triangle, with as much (if not more) Eaſe and Exactneſs as that is performed there, which encouraged me to proceed to the compleating of that New Method, which I deſigned ſhould only have been the Subject of this Treatiſe, when I firſt thought of appearing in Publick. But ſuppoſing that thoſe who had learned the whole Art of Navigation, both *Geometrical*, *Trigonometrical*, and *Inſtrumental*, as it is commonly taught in Schools, and practiſed at Sea, would be diſcouraged from buying the Book, when they found nothing in it that they had formerly learnt. Therefore for the Sake of ſuch, and to make the Book univerſally Uſeful, I reſolve to make it a compleat Treatiſe of Navigation, as performed,

Firſt, Geometrically, by Projection, with Chords and equal Parts.

Secondly, By Trigonometrical Calculation, by Logarithms, Sines and Tangents.

Thirdly, By Inſpection, in the Traverſe Table.

Fourthly, Arithmetically, by given Numbers.

Fifthly,

Fifthly, Inſtrumentally, by Scale and Compaſſes.

Sixthly, By a New Method, with only Pen and Ink.

Laſtly, Practical Navigation in ſeveral Parts; as,

Firſt, How to find the Variation of the Compaſs by an eaſy Method, without Trigonometrical Calculation, Azimuth, or Amplitude, whereby they that can neither write nor read may do it as well as the beſt Mathematician.

Secondly, How to divide the Log-Line, and Reaſons given for the Length aſſigned for one Knot thereof.

Thirdly, The beſt Method for taking and working an Obſervation, contracted into four Caſes or Varieties, which anſwers all Places in the World, and at all Times of the Year.

Fourthly, How to reckon the Tides, by a Method ſo eaſy, that you may thereby find the Time of High-Water, at any known Port, only by a Sight of the Moon, at any Time of the Day or Night, illuſtrated by a Diagram, or Figure, in which, indeed to have been exact, the light Part of the Moon's Body ſhould have been determined by Ellipſis's, and not by Arches of Circles, as is evident from the Analemma, if we compare the Poſition of the Eye, with reſpect of the Moon, with the Poſition of the Eye, with reſpect to the Orthographick Projection; but I have contented myſelf with thoſe circular Diviſions, becauſe they are eaſier performed, and

ſerve

ſerve as well to illuſtrate the Matter for which they are projected.

And here by the Way, we may take Notice of one Obſervation with Reſpect to the Tides, though for ſome Reaſons omitted in its proper Place, *viz.* Whether the Moon in Perigeon, by Reaſon of her nearneſs to the Earth, may not have a greater attractive Influence upon the Water; as alſo whether a greater Congreſs of Planets about the Sun or Moon, at the New or Full Moon, may not conduce ſomething to the augmenting the Tides, by contributing their (although but ſmall) Attraction, when other more ſubſtantial Reaſons there mentioned do concur; and this I am rather induced to believe, becauſe the Truth hereof has been confirmed to us by an Inſtance within the Reach of our own Experience; for at the New Moon in *September*, 1709, there was ſuch a Confluence of Natural Cauſes of the Tide: For firſt, the Moon was then with the Sun. Secondly, It was the Lunation next after the Autumnal Equinox. Thirdly, the Moon was at or near her Perigeon. Fourthly, The three Planets *Mars*, *Venus* and *Mercury*, were all within leſs than thirty Degrees of the Sun and Moon; yea, ſome within fifteen Degrees, and *Jupiter* was within thirty-five Degrees of the Sun and Moon; and this Lunation was attended with ſuch exuberant Tides, that in the low Ground in *Yorkſhire*, over againſt *Stockton*, where the Tide never comes but in the very high Spring-Tides, it flowed two or three Foot Water, and doubtleſs at other Places it was proportionable, which ſeems to confirm the Truth of this more than probable Conjecture, and render it worthy of the Obſervation of the Ingenious.

Fiftbly,

Fifthly, How to make your own Charts for any Voyage ſeveral Ways.

Laſtly, The Application of the Whole to the actual Keeping of a Reckoning both in Latitude and Longitude, ſailing Large, or upon a Wind; and how to make all proper Allowances for Lee-way, Variation, *&c.* and how to Correct your Reckoning by an Obſervation, with Reaſons and Demonſtrations of the different Ways of doing it. One and the ſame Days Work in the Journal, as well as one and the ſame Queſtion elſewhere in the Book, being performed both by the common Method, and alſo by the New Method, that the Reader may ſee the Truth and Certainty thereof.

With Directions ſhewing how to project and anſwer the various Caſes and Queſtions relating to Currents, with other uſeful Queſtions, and a Method for finding and correcting the Longitude without the help of the Dead Reckoning.

And that the Book may not be imperfect, or inferior to any of its Kind and Volume, I have added the neceſſary Problems in *Spherical Geometry*, with the twenty-eight Caſes of *Spherical Triangles*, and the Demonſtration of the Concluſions, by which ſeveral of the Oblique are performed, deduced from the Catholick Propoſitions made uſe of in the Sixteen Caſes of Right-angled Triangles: I have alſo given Directions for the Solution of Quadrantal Triangles, and the Application of the Whole to ſo much Practical Aſtronomy, as is uſeful in Navigation; all which is what was not in the former Impreſſions.

And

And although here are Ways propoſed for anſwering all neceſſary Caſes in Navigation without Logarithms, *&c.* yet to make the Book univerſally uſeful, and as much as can be to anſwer the End of all Buyers, as well the Learner at School, and the accompliſhed Mathematician in his Trigonometrical Operations, I have added a Correct Table of Logarithms, Sines, and Tangents, and ſome other uſeful Tables, which concludes the Whole. Thus deſiring a favourable Conſtruction to be put upon what Faults may eſcape either the Pen or the Preſs; I queſtion not the noble hearted Sailors Acceptance; and that it may be a Benefit to the Buyer, a Help to the Learner, a fit Companion for the Mariner, and a Credit to the Author, is the Deſire of,

Yours to ſerve you,

HENRY WILLSON.

THE

THE

CONTENTS.

CHAP. I.

Navigation Geometrical.

SECT. 1. *Geometrical Problems.* Page 1
Sect. 2. *The Conſtruction of the Sines, Tangents and Secants.* 3
Sect. 3. *Plane Trigonometry Geometrical.* 7
Sect. 4. *Oblique Trigonometry Geometrical.* 10
Sect. 5. *Plane Sailing Geometrical.* 12
Sect. 6. *Traverſe Sailing Geometrical.* 15
Sect. 7. *Mercator's Sailing Geometrical.* 20
Sect. 8. *Parallel Sailing Geometrical* 25
Sect. 9. *Middle Latitude Sailing Geometrical.* 30

CHAP. II.

Navigation Trigonometrical.

SECT. 1. *Plane Trigonometry.* Page 35
Sect. 2. *Oblique Trigonometry.* 40
Sect. 3. *Plane Sailing Trigonometrical* 43
Sect. 4. *Mercator's Sailing Trigonometrical, with a Method for ſupplying the Table of Meridional Parts.* 52

Sect.

Sect. 5. *Parallel Sailing Trigonometrical.* Page 62
Sect. 6. *Middle Latitude Sailing Trigonometrical* 65

CHAP. III.

Navigation by Inſpection in the Traverſe Table.

SECT. 1. *Plane Sailing by Inſpection.* 77
Sect. 2. *Traverſe Sailing by Inſpection.* 82
Sect. 3. *How to find the Difference of Longitude by Inſpection in the Traverſe Table.* 86

CHAP. IV.

Navigation Arithmetical.

SECT. 1. *Plane Sailing Arithmetical.* 89
Sect. 2. *Mercator's Sailing Arithmetical.* 100
Sect. 3. *Parallel Sailing Arithmetical.* 111
Sect. 4. *Middle Latitude Sailing Arithmetical.* 119

CHAP. V.

Navigation Inſtrumental.

SECT. 1. *Plane Sailing Inſtrumental.* 130
Sect. 2. *Mercator's Sailing Inſtrumental.* 136
Sect. 3. *Parallel and Middle Latitude Sailing Inſtrumental.* 139

CHAP.

CHAP. VI.

A New Method for ſolving any Queſtion in Plane Trigonometry, and keeping a Reckoning both in Longitude and Latitude, without Book, Table, or Inſtrument, &c. *only with Pen and Ink.*

SECT. 1. *Rules and Grounds of the Method* p. 140
Sect. 2. *Plane Sailing by a New Method* 143
Sect. 3. *Oblique Triangles, ſolved by the New Method* 150
Sect. 4. *How to find the Difference of Longitude by the New Method* 156

CHAP. VII.

Practical Navigation, or the Application of the foregoing Rule, to the actual keeping of a Reckoning, &c.

SECT. 1. *How to find the Variation of the Compaſs by an eaſy Method* 161
Sect. 2. *How to divide a Log-line, and prove a Half-Minute Glaſs* 163
Sect. 3. *How to make a Plane Chart, and alſo a Mercator's-Chart, and a True Plane Chart* 167
Sect. 4. *How to take and work an Obſervation* 175
Sect. 5. *How to know the Time of High-Water at any known Port, only by a Sight of the Moon, at any*

any Time of the Day or Night; with probable Reaſons for the Original Cauſe of the Ebbing and Flowing of the Sea, with a Table of the Moon's Changing for 15 Years. Page 179
A Tide-Table. 196
Sect. 6. *Examples in keeping a Journal, and how to give all proper Allowance for Lee-way, Variation, &c. and how to correct it by an Obſervation.* 202

CHAP. VIII.

Of the Projection of the Sphere.

SECT. 1. *Of the Orthographick Projection* 219
Sect. 2. *Of the Stereographick Projection* 225
Sect. 3. *Of Spherical Trigonometry Right-angled* 236
Spherical Trigonometry Oblique 244

TABLES

In the Second PART.

A Table of Difference of Latitude and Departure 257
A Table of Meridional Parts 279
Tables of the Sun's Declination 289
A Table of the Latitude and Longitude of Places 298
A Table of the Sun's Right Aſcenſion 316
A Table of the fixed Stars 318
Of Currents 321
Pleaſant Queſtions 345
To find the Longitude 362
Aſtronomy 377

NAVIGATION

New Modell'd.

CHAP. I.

NAVIGATION *Geometrical.*

SECT. I.

Geometrical Problems.

PROB. I. *From a Point given in the Middle of a Line, to erect a Perpendicular.*

WITH your Compaſſes opened at any Extent, and one Foot in the given Point A, make the Marks *b* and *c*; then with any greater Extent, and one Foot in *b*, make an Arch, as at *d*, and with the ſame Extent, and one Foot in *c*; croſs the ſaid Arch at *d*; then from the croſſing of the ſaid Arches to the Point A, draw a Line, it is the Perpendicular required. *Fig.* 1.

PROB. II. *From a Point given above a Line, to let fall a Perpendicular.*

With your Compaſſes opened at any Extent (more than the neareſt Diſtance from the given Point to the given

Line) and one Foot in the given Point A, croſs the given Line in *b* and *c*; then with any Diſtance more than half the Diſtance between *b* and *c*, and one Foot in *b* draw the Arch *d*, and with the ſame Extent, and one Foot in *c*, croſs the ſaid Arch at *d*; then lay a Scale from the Point A to the Croſſing of the Arches at *d*, ſo draw the Line AE, which is the Perpendicular required.

Fig. 2.

PROB. III. *How to raiſe a Perpendicular upon the End of a given Line.*

With your Compaſſes at any Extent, and one Foot in the given Point A, make a Mark at any convenient Diſtance above the Line, as at *b*; then keeping one Foot in the Mark *b*, with the ſame Extent croſs the given Line at *c*, and turning your Compaſſes about, make the Arch *d*; then lay a Scale from the Croſſing at *c* to the Mark at *b*, and make a Mark where it croſſes the Arch *d*; ſo a Line drawn from that Interſection to the Point A is the Perpendicular required.

Fig. 3.

PROB. IV. *How to let fall a Perpendicular upon the End of a given Line, from any given Point over the End of the ſaid Line.*

Draw a Line from the given Point A to interſect the given Line at any convenient Diſtance, as at *b*; then divide the Line A *b* into two equal Parts at *c*; and upon *c*, with the Extent *c* A, or *c b*, croſs the given Line in *d*; then a Line drawn from the given Point A to the Interſection at *d*, is the Perpendicular required.

Fig. 4.

PROB. V. *To draw a Line parallel to another Line at any given Diſtance.*

Take in your Compaſſes the given Diſtance, and with one Foot in the given Line, towards each End of it, draw the two little Arches *a* and *b*: a Line drawn from the Extremity of theſe Arches is the Parallel required.

Fig. 5.

PROB.

PROB. VI. *To bring any three Points (not ſituate in a right Line) into the Circumference of a Circle.*

Suppoſe the three Points be ABC; firſt take more than half the Diſtance A B, and with one Foot in A, ſweep an Arch; then with the ſame Diſtance, and one Foot in B, draw another Arch to croſs the aforeſaid Arch in the Points *d* and *e*; then with more than half the Diſtance BC, and one Foot in B, draw the Arch *g h*, and with the ſame Diſtance, and one Foot in C, draw an Arch to croſs the aforeſaid Arch in the Points *g* and *h*; then draw the Lines *a e d*, and *a g h*, and where theſe Lines croſs, as at *a*, is the Center of the Circle required. *Fig.* 6.

SECT. II.

The Conſtruction of Sines, &c.

EVERY great Circle is (ſuppoſed to be) divided into 360 equal Parts, called Degrees, whereof the Half, or Semicircle, contains 180 Degrees, and the Quarter or Quadrant is 90 Degrees, and upon one Quadrant is projected the Sines, Tangents, *&c.*

The Radius is the Semidiameter of a Circle, upon which the Projection is made; as A K, or A 90, or A S, is the Radius of the projected Diagram, and is commonly ſuppoſed to contain 10000 equal Parts.

A Sine is a Perpendicular let fall from the given Degree to the Baſe or Semidiameter of the Circle; as the Line *g* 30, is the Sine of 30 Degrees, and the Line *b* 80, is the Sine of 80 Degrees, *&c.* the Sine of 90 Degrees is equal to the Radius.

A Tangent, or Touch-line, is a Perpendicular erected upon the End of the Semidiameter, juſt ſo as to touch the Periphery of the Circle: Thus the Line K T is a Tangent Line. The Tangent of any De- *Fig.* 7.

gree is the Diſtance from the Beginning or Foot of the Tangent Line to that Part of it where the Line, drawn from the Center over the given Degree, cuts the Tangent Line: Thus the Part of the Tangent Line *k p* is the Tangent of 50 Degrees. The Tangent of 45 is equal to the Radius.

A Secant is a Line drawn from the Center through the given Degree 'till it interſect the Tangent Line: Thus the Line A *p* is the Secant of 50 Degrees. The Secants begin at the Radius, and proceed to Infinite. The Secant of 0 Degrees being equal to the Radius.

A Chord is the neareſt Diſtance in a ſtrait Line between any Quantity of Degrees; or from 0 Degrees to the Degree whoſe Chord is required: Thus the Line S. 90 is a Line of Chords, and the Diſtance S. 30 upon that Line is the Chord of 30 Degrees, *&c.* the Chord of 60 Degrees is equal to the Radius; and hence it is, that the Chord of 60, commonly called the Sweep of 60, is generally taken in the Compaſſes to draw any Great Circle, or Arch of a Circle, whoſe Quantity in Degrees is to be meaſured.

The Sine-Complement of any Arch, is the Sine of the Complement of that Arch to 90: Thus the Sine complement of 30 Degrees is the Sine of 60, and the Sine-complement of 70 is the Sine of 20, *&c.* And in the Diagram the Line W 40 (equal to the Diſtance A *f* upon the Baſe) is the Sine-complement of 40 Degrees, and ſo in others.

A verſed Sine is a Segment of the Baſe, contained between the Sine of the Degree and the End of the Baſe where the Tangent Line begins; thus the Segment of the Baſe *e* K is the verſed Sine of 50, *&c.*

From this Projection is reduced the following *Axioms* for the Solution of all the Caſes in Plane Trigonometry; and which (if well underſtood) are the Ground of the whole Art of Navigation, ſo far as it depends upon Plane Triangles, and is ſolved by a Canon; which I ſhall firſt ſhew in the following Caſes, and then proceed to ſhew how it may be done without.

AXIOM

AXIOM I.

In all right-angled Plane Triangles, if one Side be made Radius, the other Sides will be Sines, Sine-complements, Tangents or Secants, as is evident from the Diagram; for,

Suppoſe in the Diagram the Triangle A *p* K, here the Side A K is the Radius, and the Angle at A being 50 Degrees, the Side *p* K is the Tangent of 50, and the Hypotenuſe A *p* is the Secant of 50; and what Proportion the *Radius* hath to the Sine A K, the ſame Proportion hath the Tangent of 50 to the Side K *p*, and the ſame Proportion hath the Secant of the Hypotenuſe A *p*.

Again, if you will make the Hypotenuſe Radius, and ſuppoſe the Angle at A be 40 Degrees; then in the Diagram it is repreſented by the Triangle A *f* 40, and then the Side *f* 40 is the Sine of the Angle at A, and the Side A *f* equal to W 40 is the Sine-complement of the Angle at A, and then what Proportion the Hypotenuſe hath to the Radius, the ſame Proportion will the Sine 40 *f* have to the Sine of 40, and the ſame Proportion will the Side A *f* have to the Sine-complement of 40, *&c.* and from this Proportion proceeds the ſecond Axiom.

AXIOM II.

In all Plane Triangles the Sides are proportionable to the Sines of their oppoſite Angles, and the contrary; as in the Diagram in the Triangle above-mentioned, A *f* 40, it is demonſtrated, As the Radius or Sine of 90 to the Hypotenuſe, or Side oppoſite; ſo is the Sine of 40 to the Side oppoſite to the Angle at A, *&c.*

This Proportion commonly called Oppoſite Sides Oppoſite Angles, holds true alſo in Oblique Plane Triangles; only obſerve, that where you have an Obtuſe Angle, *viz.* more than 90 Degrees, the Sine of it is found by ſubtracting the Obtuſe Angle from 180 Degrees, the Sine of the Remainder is the Sine of the Obtuſe Angle required.

AXIOM III.

In all Triangles, as the Sum of the Legs of any Angle is to their Difference, ſo is the Tangent of half the Sum of the other two Angles, to the Tangent of half their Difference; and therefore,

When there are given two Sides, and an Angle included, to find the other Angles, the Proportion is,

As the Sum of the Sides, to the Difference of the Sides, ſo is the Tangent of half the Sum of the unknown Angles, to the Tangent of half their Difference; which half Difference added to the half Sum, is the greater Angle, and ſubtracted leaves the leſſer.

AXIOM IV.

In all Triangles, as the Baſe or greater Side, to the Sum of the other two Sides; ſo the Difference of the Sides to the Difference of the Segments of the Baſe, which Difference ſubtracted from the whole Baſe, the Perpendicular falls in the Middle of the Remainder; and ſo the Oblique Triangle is reduced to two Right-angled ones, and may be wrought after the ſame Manner.

By theſe Axioms are all the following Caſes of Plane Triangles ſolved; in which obſerve, In Right-angled Triangles, the two Sides including the Right-angle are called Legs or Sides, or ſometimes Baſe or Perpendicular; and the ſlope Line is called the Hypotenuſe.

SECT.

SECT. III.

Plane Trigonometry Geometrical.

Plane Trigonometry Right-angled.

CASE. I. *The Hypotenuſe, and one accute Angle being given (conſequently both) to find either Leg.*

Note, IN all Plane Triangles, the three Angles make up 180 Degrees, therefore in all Right-angled Triangles, becauſe the Right-angle is always 90, the Sum of the other two Angles is alſo 90, and therefore ſubtract the acute Angle given from 90, the Remainder is the other acute Angle.

Given Hypotenuſe AC 550.
The Angle at —— A 35d. 00m. *Fig.* 8.
Required the Leg AB.
And the Leg BC.

1. In this, and all other Caſes, draw the Baſe AB at Pleaſure.

2. With the Chord of 60, and one Foot in A, ſweep the Arch *A e.*

3. With the Chord of the given Angle 35, and one Foot in *d*, with the other Foot croſs the Arch at *e.*

4. From A through *e*, draw the Line AC, upon which ſet off the Hypotenuſe 550 from A to C.

5. From C let fall the Perpendicular upon the Line AB to cut it in B, and 'tis done.

The Leg AB meaſured on the ſame equal Parts from which the Hypotenuſe was taken, will be found to be 450.5, *viz.* 450 and an half, and the Leg BC is 315.5.

CASE II. *Given the Angles and a Leg, to find the Hypotenuſe.*

Given the Angle A ——— 33d. 45m.
Fig. 9. the Leg AB ——— 449
Required the Hypotenuſe AC.

1. Draw AB 449.
2. With the Sweep of 60, and one Foot in A, draw the Arch *d e*.
3. With the Chord of the given Angle, and one Foot in *d*, ſet off the given Angle 33d. 45m. from *d* to *e*.
4. From B erect a Perpendicular BC.
5. Through A and *e* draw the Hypotenuſe AC, till it croſs BC, and 'tis done.

The Hypotenuſe AC meaſured on the Scale of equal Parts will be found to be 540.

CASE III. *Given the Angles and a Leg, to find the other Leg.*

Given the Angle A ——— 33d. 45m.
the Leg AB ——— 449d.
Required the Leg BC.

This is laid down as Caſe II. the ſame Things being given, and the required Leg BC being meaſured, will be found to be 300.

CASE IV. *Given the Hypotenuſe and the Leg, to find an Angle.*

Given the Hypotenuſe AC 540
Fig. 10. the Leg AB ——— 449
Required the Angle at A.

1. Draw AB at Pleaſure.
2. Upon AB ſet off the given Leg 449, from A to B.
3. From B erect a Perpendicular.
4. With the Hypotenuſe 540, and one Foot in A croſs the Perpendicular BC in C.
5. From the ſaid croſſing to A draw the Line CA.
6. With the Sweep of 60, and the Foot in A, draw the Arch *d e*, and 'tis done.

The Arch *d e* meaſured on the Chords gives 33d. 45m, the Angle required.

CASE

CASE V. *Given the Hypotenuſe and a Leg, to find the other Leg.*

Given the Hypotenuſe AC 540
the Leg AB —— 449
Required the Leg BC.

The laying down of this is the ſame as the former, becauſe the ſame Things are given; and the Leg BC meaſured on the ſame equal Parts from whence the given Parts are laid down, will be found to be 300.

CASE VI. *The Legs given, to find the Angle.*

Given the Leg AB —— 449
the Leg BC —— 300 *Fig.* 11.
Required the Angles.

1. Draw AB 449.
2. Upon B erect the Perpendicular BC, and thereupon ſet off 300 from B to C.
3. Draw the Hypotenuſe AC.
4. With the Sweep of 60, and one Foot in A, draw the Arch *d e*, and 'tis done.

The Arch *d e* meaſured on the Chords gives 33d. 45m. the Angle required.

CASE VII. *The Leg given, to find the Hypotenuſe.*

Given the Leg AB —— 449
the Leg BC —— 300
Required the Hypotenuſe AC.

This is laid down as *Caſe* VI. and the Hypotenuſe AC meaſured on the Scale of equal Parts is 540.

Note; *Theſe ſeven Caſes may be reduced to four, for making the firſt Caſe as above to be the firſt Caſe; the ſecond and third having both the ſame Things given may be called the ſecond, and for the ſame Reaſon, the fourth and fifth may be comprized in one, and called the third; and the ſixth and ſeventh having alſo the ſame Things given, may then be called the fourth Caſe, and at this Rate the ſeven Caſes are comprehended in four, becauſe four Times laying down includes all the Varieties of Right-angled Plane Triangles.*

SECT.

SECT IV.

Of Oblique Plane Triangles.

CASE I. *Two Angles and a Side oppoſite to one of them given, to find the Side oppoſite to the other.*

Given the Angle at A ——— 30d. om.
Fig. 12. the Angle at B ——— 45d. om.
the Side BC ——— 290
Required the Side AC.

1. Draw AB at Pleaſure.
2. With the Chord of 60, and one Foot in B (the Angle next the given Side) draw the Arch *d e*.
3. Upon that Arch ſet off the Chord of the given Angle 45, from *d* to *e*.
4. From B through *e* draw the Line BC, and upon it ſet off the given Side 290 from B to C.
5. The Angles A and B being given, the Angle C is alſo known, being the Complement of the other two Angles to 180, and will be found to be 105d. and therefore with 60 of the Chords, and one Foot in C, ſweep the Arch F *g*, upon which ſet off 105d. from F to *g*, and through *g* draw the Line CA to cut AB in A, and 'tis done.

The Side AC meaſured on the ſame equal Parts is 410, the Side required.

Note; When you have any Chord above 90 to ſet off, you muſt do it at twice, becauſe the Chords go but to 90, &c.

CASE II. *Two Sides and an Angle oppoſite to one of them given, to find the Angle oppoſite to the other.*

Given the Side AB ——— 580
Fig. 13. the Side AC ——— 410
the Angle at B —— 45d. om.
Required the Angle at C.

1. Draw

1. Draw AB 560.
2. Make the Angle B 45, and draw the Line BC.
3. With the Side AC 410, and one Foot in A, croſs the Line BC in C, and draw the Line AC, and 'tis done.

The Angle at C meaſured on the Sweep *d e*, gives 105d. the Angle at C required.

Note; This Caſe is ambiguous, and will admit of two Anſwers; ſo that it is neceſſary that it be known whether the Angle at C be acute (that is, leſs than 90) or obtuſe (that is, more than 90) for if it be obtuſe, the Angle marked C is the Angle required; but if acute, the Angle at O is it; for the Side AC 410 taken in the Compaſſes, and one Foot in A, it will croſs the Line BC (continued) both in C and O, *&c.*

CASE III. *Given as in Caſe* II. *to find the third Side.*

The laying down is the ſame as in *Caſe* II. becauſe the ſame Things are given; and the Side BC meaſured on the equal Parts is 290, if the Angle be obtuſe; or 503, if it be acute.

CASE IV. *Two Sides and an Angle between them given, to find either of the other Angles.*

Given the Side AC ——— 410 *Fig.* 14.
the Side AB ——— 560
the Angle at A —— 30d. 0m.
Required the Angle B.

1. Draw AB 560 from A to B.
2. Make the Angle A 30d. 0m.
3. Draw AC 410 from A to C.
4. From C to B draw the Side CB, and 'tis done.

The Angle B meaſured on the Chords is 45d. 0m.

CASE V. *Given two Sides, and the Angle between them, to find the third Side.*

Given the Side AC ——— 410
the Side AB ——— 560
the Angle A ——— 30d.
Required the Side BC,

Lay down as in *Caſe* IV. and the Side BC meaſured is 290.

CASE

CASE VI. *Three Sides given to find an Angle.*

Given the Side AB ——— 560
the Side AC ——— 410
the Side BC ——— 290
Required the Angle at A.

1. Draw AB 560 from A to B.
2. Take the Side AC 410 in your Compaſſes, and with one Foot in A, draw an Arch at C.
3. With the Side BC 290 in your Compaſſes, and one Foot in B, croſs the Arch at C.
4. From the croſſing of the ſaid Arches to A and B, draw CA and CB, and 'tis done.

The Angle at A meaſured on the Chords is 30d. 00m.

SECT. V.

Plane Sailing Geometrical.

IN laying down all the Caſes of Plane Sailing, Traverſe, Mercator, *&c.* obſerve to make the Top of the Book or Slate North, and the Bottom South; the Right-hand Eaſt, and the Left-hand Weſt, *&c.*

Obſerve, that in the Application of Right-angled Triangles, to Queſtions of Plane Sailing, the Courſe is always the Angle at the Baſe: The Diſtance is the Hypotenuſe: The Difference of Latitude is the North and South Line; and the Departure is the Eaſt and Weſt Line of the Triangle.

Thus in the four Triangles, *Fig.* 16, N° 1, repreſents a Courſe in the N. E. Quarter; N° 2, a Courſe in the S. E. Quarter; N° 3, a Courſe in the S. W. Quarter; N° 4, a Courſe in the N. W. Quarter: And in each of theſe Triangles the Point A repreſents the Place ſailed from, and the Point C the Place ſailed to: And the Angle at A is the Courſe, the Angle at C its Complement, the

Fig. 16.

the Hypotenuſe AC, the Diſtance, the Leg AB the Difference of Latitude, and the Leg BC the Departure, *&c.*

CASE. I. *Courſe and Diſtance given, to find the Difference of Latitude and Departure.*

A Ship ſails S.W. by S. 540 Miles, I demand the Difference of Latitude and Departure.

1. In this and all other Caſes of Plane Sailing, draw the North and South Line AB.

2. The Courſe being three Points from the Meridian, *viz.* 33d. 45m. make the Angle at A 33d. 45m. from *d* to *e*. *Fig.* 17.

3. Thro' *e* draw the Hoyptenuſe (or Diſtance) AC 540 from A to C.

4. From C let fall a Perpendicular CB to cut AB in B, and 'tis done.

The Difference of Latitude AB meaſured is 449, and the Departure BC is 300, *&c.*

CASE. II. *Courſe and Difference of Latitude given, to find the Diſtance and Departure.*

A Ship Sails S.W. by S. till her Differencr of Latitude be 449, I demand her Diſtance and Departure.

1. Make AB the Difference of Latitude 449, from A to B. *Fig.* 18.

2. Upon B erect the Perpendicular BC at Pleaſure.

3. Set off the Courſe 33d. 45m. and draw the Hypotenuſe AC to cut BC in C, and 'tis done.

The Diſtance AC meaſured will be found to be 540, and the Departure BC meaſured is 300 Miles.

CASE III. *Courſe and Departure given, to find the Diſtance and Difference of Latitude.*

A Ship ſails N.E. by N. till her Departure be 300 Miles, her Diſtance and Difference of Latitude is required.

1. Draw AB at pleaſure.

2. At

2. At the Diſtance 300 the Departure given,
Fig. 19. draw the Parallel Line *d e*.

3. With the Angle of the Courſe 33d. 45m. draw the Hypotenuſe AC, to cut the Parallel in C.

4. From the croſſing at C, let fall the Perpendicular CB, to cut AB in B, and 'tis done.

Another Way to lay it down.

1. Draw AB at Pleaſure.

2. Upon the North End thereof (becauſe the Ship ſails to the Northward) erect a Perpendicular BC, upon which ſet off the Departure 300.

3. Make the Angle at C 56d. 15m. the Complement of the Courſe, and draw the Hypotenuſe CA, to cut AB in A, and 'tis done.

The Diſtance AC is 540.

The Difference of Latitude AB is 449.

CASE IV. *Diſtance and Difference of Latitude given, to find the Courſe and Departure.*

A Ship ſails in the S.E. Quarter 540 Miles, and then finds her Difference of Latitude is 449, her Courſe and Departure is required.

1. Make the Difference of Latitude AB 449, from A to B, and upon B erect the Perpendicular BC.

Fig. 20. 2. Take the Diſtance in your Compaſſes, and with one Foot in A croſs the Perpendicular BC in C.

3. From the croſſing C to A draw AC.

4. With the Chord of 60 make the Arch *d e*, and 'tis done.

The Arch *d e* meaſured on the Rhumbs, is three Points, or on the Chords is 33d. 45m.

The Departure BC is 300.

CASE V. *Diſtance and Departure given, to find the Courſe and Difference of Latitude.*

A Ship ſails between the N. and W. 540 Miles, her Departure is 300; I demand her Courſe, and Difference of Latitude.

1. Draw

1. Draw AB at Pleaſure.

2. At B erect the Perpendicular BC, and ſet off the Departure 300 from B to C. *Fig.* 21.

3. With the Diſtance 540 in your Compaſſes, and one Foot in C, croſs the Line AB in A.

4. From C to the Croſſing at A draw AC.

5. With the Chord of 60, and one Foot in A, make the Arch *d e*, and 'tis done.

AB the Difference of Latitude is 449, and the Courſe *d e* is three Points, or 33d. 45m.

CASE VI. *Difference of Latitude and Departure given, to find the Courſe and Diſtance.*

A Ship ſails in the S.W. Quarter, till her Difference of Latitude be 449, and her Departure 300; her Courſe and Diſtance is required.

1. Draw the Difference of Latitude AB 449, from A to B.

2. Upon B erect the Perpendicular BC, upon which ſet off the Departure 300, from B to C. *Fig.* 22.

3. From A to C draw the Hypotenuſe AC.

4. With the Chord of 60, make the Arch *d e*, and 'tis done.

The Diſtance AC is 540, and the Angle at A, the Courſe three Points, or 33d. 45m.

SECT. VI.

Traverſe Sailing Geometrical.

TRaverſe Sailing is of Uſe, when a Ship having ſet ſail from one Port intending for another, whoſe Courſe and Diſtance from the Port ſailed from, is given or known; but by Reaſon of contrary Winds, or other Accident, is forced to ſail upon ſeveral Courſes, which are required to be brought into one Courſe, to know thereby

thereby (after ſo many various Turnings and Windings) the true Courſe and Diſtance made good from the Place ſailed from, and the true Point or Place where the Ship is; (that ſo the Wind coming fair) it may be known how to ſhape a Courſe for the Place intended; and this, which is the chief Subject of Traverſe Sailing, may be performed Geometrically two Ways, both which I ſhall briefly lay down.

The firſt is performed by drawing new Meridians through the Extremity of every Courſe, parallel to the firſt Meridian, or North and South Line, that you make at the firſt, and ſo ſet off every Courſe with a Sweep of 60, as if it were a Queſtion of Plane Sailing. You may alſo let fall Perpendiculars to every new Meridian from the Point that the Ship ſailed to upon that Courſe, and ſo you have the Courſe, Diſtance, Difference of Latitude and Departure, to every Courſe; and this Method is very uſeful where the Courſes tend generally all one Way, without interſecting one another. But if your Courſes frequently croſs one another, 'tis beſt to lay them down without new Meridians, *viz.* to ſet off one Courſe by another; for which Mr. *Atkinſon* in his Epitome laid down four Rules; but they being ſo burthenſome to the Memory of young Learners, I ſhall not ſo much as name them; but ſhall lay down one Rule which is univerſally uſeful in all Caſes, and eaſily remembered, and 'tis this;

Obſerve how many Points are between the Point next to be laid down, and the Point oppoſite to the Courſe laſt laid down, for that is the Point for laying down; thereſore with the Chord of 60, and one Foot in the Point the Ship is laſt come to, deſcribe an Arch; upon which ſet off the Points found by the aboveſaid Rule, and through that draw the Line for the next Courſe, *&c.*

I ſhall explain both Ways by Example; and firſt,

How to lay down a Traverſe by new Meridians.

A Ship bound for a Port diſtant 120 Miles N. E. ½ E. ſails S.S.E. 30 Miles, then N.E. by N. 40, then E. by N. 25, then N.N.E. 44; I demand the Courſe and Diſtance made good, and alſo the Courſe and Diſtance to the Port bound for. Firſt,

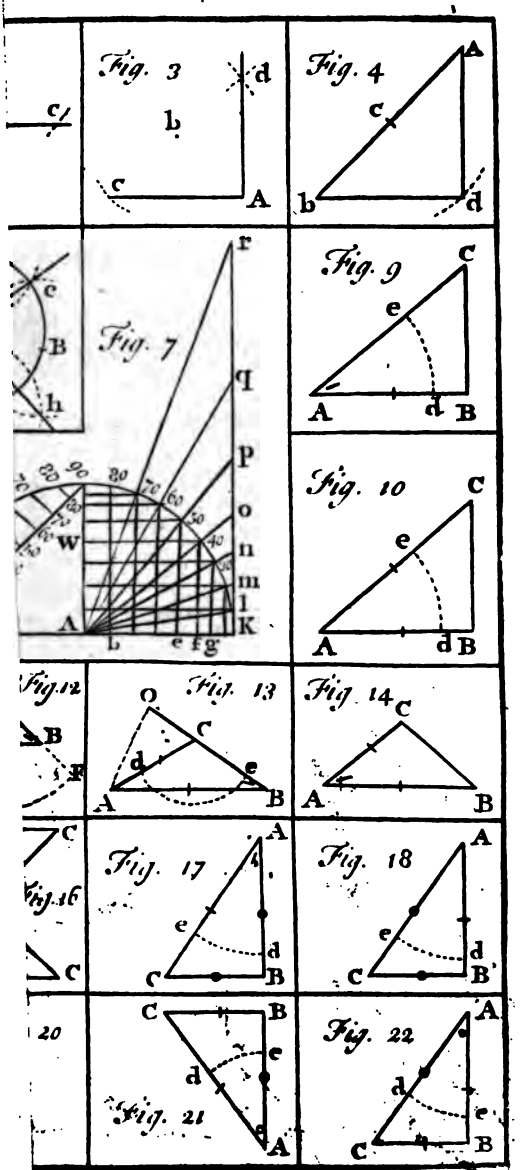


Fig. 3
d
b
c
A
Fig. 4
A
c
b
d
B
h
Fig. 7
r
q
p
o
n
m
l
K
W
A
b
e f g
Fig. 9
C
e
A
d
B
Fig. 10
C
e
A
d
B
Fig. 12
B
Fig. 13
O
C
d
e
A
B
Fig. 14
C
A
B
C
Fig. 16
C
Fig. 17
A
e
d
C
B
Fig. 18
A
e
d
C
B
20
C
B
e
d
Fig. 21
A
Fig. 22
A
d
e
C
B

Firſt, Draw the Line K H at pleaſure, for a Meridian, or North or South Line; and therein aſſume a Point, as at A, for the Port ſailed from; then with 60 of the Chords, and one Foot in A, draw the Arch L *m*, upon which ſet off two Points, (becauſe the Courſe is S.S.E.) from L to *m*, and draw the Line A *m*, upon which ſet off the Diſtance 30 from A to B, then is your Ship at B; then let fall the Perpendicular B K, then is A K, 27.7. the difference of Latitude, and B K, 11.5 the Departure for the firſt Courſe——Then for the ſecond Courſe, with the Diſtance K B draw the Parallel B N, and thereby, with the Chord of 60, as before, ſet off the ſecond Courſe and Diſtance N.E. by N. 40, from B to C, and let fall the Perpendicular C L, then is your Ship at C, the Difference of Latitude upon that Courſe is B L 33.3, and the Departure C L 22.2:——Then proceed in the ſame Manner for the third Courſe; with the Parallel C O, ſet off E. by N. 25, from C to D, and draw the Line D P, (from which ſet off the laſt Courſe, N.N.E.) 44. then is your Ship at E. Now ſeeing the Ship came from A, and is now at E, the Line A E meaſured on the ſame equal Parts, upon which all the other Diſtances were taken, will be found to be 91 Miles, and the Arch R Q meaſured on the Rumbs is five Points, *viz.* N.E. by E. ſo that the Ship is now 91 Miles, N.E. by E. from the Port ſailed from.

Now to find her Courſe and Diſtance to the Port bound for, ſet off four Points and a Half upon the Arch R Q, from R to S, and from A thro' S draw the Line A S F; upon which ſet off 120 (the Diſtance from the Port ſailed from to the Port bound for) from A to F, then is F the Port bound for; now the Port bound for being at F, and the Ship being but at E, therefore the Line E F meaſured on the ſame equal Parts that the reſt was taken from, will be found to be 31, and the Arch T V meaſured on the Chords is 35d. 12m. or N.E. by N. ſomewhat Eaſterly, *&c.* *Fig.* 23.

How to lay down a Traverſe without new Meridians.

Firſt, Draw a North and South Line, as in the former, as the Line RM; in which aſſume a Point, as at A, for

the Port ſail'd from; then from A ſet off the firſt Courſe and Diſtance, *viz.* N.N.W. 68, from A to B; then for the ſecond Courſe, with the Chord of 60, and one Foot in B; draw the Arch TW, upon which, for ſetting off the next Courſe S.S.W. 70, obſerve the Rule at the Beginning of Traverſe Sailing Geometrical, *viz.* Take the Number of Points between the Point oppoſite to the laſt Courſe ſail'd, and the Point you are next to ſail. The Reaſon of this Rule is this: If from A to B your Courſe be N.N.W. then back from B to A muſt needs be S.S.E. (the oppoſite Point) and then if you were to ſail S. by E. it muſt be one Point to the Southward of that S.S.E. Line; if South it is two Points, and conſequently my next Courſe being S.S.W. I ſet off four Points from T to W, and through W draw the Line BC, which is a S.S.W. Line, upon which ſet off 70 Miles from B to C, and then is your Ship at C: Then for the third Courſe, if from B to C be S.S.W. then from C to B is N.N.E. but my next Courſe being E. half N. the Points between N.N.E. and E. half N. are five Points and a half; therefore, with the Chord of 60, and one Foot in C, draw the Arch *x y*, upon which ſet off five Points and an half from *x* to *y*, and thro' *y* draw the Line CD, upon which ſet off 90 Miles from C to D, then is your Ship at D; after the ſame Manner lay down all the reſt as DE W.N.W. half N. 79; then EF South 25; then FG, E. half S. 45; then laſtly, GH South 30, which is the laſt Courſe: Then your Ship being at H, and the Port ſailed from at A, the Line AH 28 Miles is the Diſtance made good, and the Angle at A is four Points, *viz.* S. E. but the Port intended for being S. W. 55. I ſet it off from A to K, but the Ship being at H the Line HK 62 Miles is the Diſtance from the Ship to the Port bound for, and the Courſe is found by meaſuring the Angle at H 7rd. 48m. or W.S.W. more than one Quarter Weſterly.

The Queſtion. A Ship at A bound for a Port at K, which bears S.W. from A diſtant 55 Leagues, but meeting with contrary Winds, ſhe ſails N. N.W. 68 Leagues, then S.S.W. 70 Leagues, then E. half N. 90 Leagues, then W.N.W. half N. 70 Leagues, then S. 25 Leagues, then E. half S. 45 Leagues, then

Fig. 24.

then South 30 Leagues; I demand the Courſe and Diſtance made good, and Courſe and Diſtance to the Port bound for.

How to tranſcribe a Traverſe, or any other right-lined Figure from the Slate to a Book, or from one Book to another.

In the firſt Line R M make two or three Marks, as at R, A and M; then in the Book in which you would lay down, draw alſo the ſame Line, and take the Diſtance R A, and ſet from R to A in the new Draught; likewiſe ſet the Diſtance A M from A to M; then for laying down the Courſes; as firſt, from A to B, with the Diſtance A B in the old Draught, and one Foot in A in the new Draught, make an Arch at B; then with the Diſtance M B in the old Draught, and one Foot in M in the new Draught, croſs the former Arch at B; then from A, and the croſſing of theſe Arches, draw the Line A B; then for the Line BC, with the Diſtance R C, and one Foot in R, draw a ſmall Arch, and with the Diſtance BC, and one Foot in B, (or with the Diſtance M C, and one Foot in M) draw an Arch to croſs the former in C, then from B to that croſſing draw the Line BC, and ſo in the reſt of the Courſes. And note, you need not regard what two Points you take in the whole Draught for the fixed Point of your Compaſſes, provided you take the ſame Points in the new Draught, only obſerve to take two Points, ſo as that the Arches may fairly croſs one another; or elſe you cannot ſo well find the Point of Interſection; as ſuppoſing you would find the Point B, if you take the Diſtance AB, and ſet from A to B, and make an Arch; and then if you take the Diſtance R B, and ſet from R to B and croſs the former Arch, theſe two Arches will run ſo along one another, that you cannot diſcern exactly the Place of Interſection; to remedy which, take two Marks that bear more ſquare from B, as A and M, and then the Arches will croſs more directly, and the Operation will be more exact. *Fig.* 25.

SECT. VII.

Mercator's *Sailing Geometrical.*

MErcator's Sailing is laid down by a right-angled Triangle, as Plane-Sailing, only the Triangle hath two Perpendiculars, the ſhorter repreſenting the Departure, as in Plane-Sailing, and the longer is the Difference of Longitude.

Thus in the Triangle A D E, A repreſents the Place ſailed from; the Angle at A is the Courſe, and the Side A B is the proper Difference of Latitude, and B C the Departure, as in Plane-Sailing. The whole Baſe A D is the Meridional Difference of Latitude; and the Perpendicular D E is the Difference of Longitude; and ſeeing the Angle at A is common to both Triangles, A B C and A D E, therefore the Baſe A B is in Proportion to the Perpendicular B C, as the whole Baſe A D is to the Perpendicular D E; and hence comes the Proportion; as proper Difference of Latitude to Meridional Difference of Latitude, ſo is the Departure to the Difference of Longitude. *Euclid lib.* 6. *Prop.* 6.

Fig. 26.

The Meridian Line, with the Scale of equal Parts next to it, upon the Scale, are of uſe for laying down Queſtions in Mercator's Sailing; they are the two loweſt Lines upon the Scale, the Meridian Line mark'd [Merid.] and the equal Parts marked [Eq. P.] the Graduations of the Meridian Line increaſes, and the Degrees of Latitude grow bigger near the Poles; the Diſtance and proper Difference of Latitude may be taken off the equal Parts, and the Meridional Difference of Latitude of the Meridian Line, if the Queſtion be ſo large as to permit it. Nevertheleſs, in ſmall Queſtions, and ſhort Diſtances, where the Diſtance between the two Latitudes upon the Meridian Line is too little to make a handſome Figure, you may find the Meridional Difference of Latitude, by the Table of Meridional Parts, and ſo take both it and the proper Difference of Latitude, with the Departure, Diſtance, and Difference of Longitude, off any equal Parts

that

that you think will be proportionable to the Dimenſions that you would have your Queſtion to contain; only take Care, that from whatſoever equal Parts you take the given Sides, you muſt meaſure the required Sides, (when found) upon the ſame equal Parts. I ſhall inſtance both Ways, in the following Examples.

CASE I. *One Latitude, Courſe and Diſtance given, to find the other Latitude, and Difference of Longitude.*

A Ship in Latitude 50d. 0m. North, ſails N.W. by N. 987 Miles, I demand the Latitude come to, and Difference of Longitude.

1. Draw ABD at pleaſure.

2. At an Angle of 33d. 45m. draw AC continued, upon which from the equal Parts ſet off the Diſtance 987 from A to C.

3. Let fall the Perpendicular CB.

4. Meaſure AB the Difference of Latitude 820 min. or 13d. 40m. which added to Latitude 50, gives the Latitude come to, 63d. 40m.

5. Extend the Compaſſes upon the Meridian Line from 50 to 63d. 40m. and ſet that Extent upon the Line AD, from A to D; then is AD 1519, the Meridional Difference of Latitude. *Fig.* 27.

6. From D erect the Perpendicular D E, to cut A C E and E, and 'tis done.

Then is AB 820 min. or 13d. 40m. the Difference of Latitude, which added to the Latitude ſailed from (becauſe the Ship ſails to the Northward) produces 63d. 40m. the Latitude come to.

DE 1017 is the Difference of Longitude required.

CASE II. *Both Latitude and Courſe given, to find the Diſtance and Difference of Longitude.*

A Ship in Lat. 56d. 25m. North, ſails N.N.E. into Latitude 68d. 30m. I demand as above.

1. Extend the Compaſſes on the Meridian Line from Lat. 56d. 25m. to Lat. 68d. 30m. and ſet that Extent on the Line A D, from A to D. *Fig.* 28.

2. Take 725 (the proper Difference of Latitude, in Minutes) from the equal Parts under the Meridian Line, and ſet upon the Line AD, from A to B.

3. At an Angle of 22d. 30m. (the Courſe given) draw the Hypotenuſe ACE.

4. At B and D erect the Perpendiculars BC and DE, and 'tis done.

Then is AC 785 the Diſtance, and DE 660 is the Difference of Longitude required.

☞ *Note*, Upon the equal Parts under the Meridian Line, every Degree being 60 Minutes or Miles, every 10 Degrees is 600 Miles; and ſo for 660, ſet one Foot in 10, the other extended one whole Diviſion beyond the Cypher towards the Right-hand is 660, and two Diviſions is 720, *&c.*

CASE III. *One Latitude, Courſe, and Difference of Longitude given, to find the other Latitude and Diſtance.*

A Ship in Lat. 50 ſails N.N.W. till her Difference of Longitude be 7 Deg. or 420 Minutes; I demand as above.

1. Draw ABD at pleaſure.

2. At an Angle of 22d. 30m. draw the Hypo-
Fig. 29. tenuſe AC continued.

3. At the Diſtance of 420 (the Difference of Latitude, draw a Line parallel to AD.

4. From the Point where that Parallel interſects the Hypotenuſe, as at E, let fall the Perpendicular DE.

5. With the Extent AD, and one Foot in the given Latitude 50 upon the Meridian Line, extend the other upward, becauſe the Ship ſails to the Northward, and the other Foot will light upon 59d. 40m. the Latitude come to.

6. With the proper Difference of Latitude 580 (off the equal Parts) and one Foot in A, find the Point B in the Line ABD.

7. At B erect the Perpendicular BC, and 'tis done.

Then is AB 580 the proper Difference of Latitude, which reduced into Degrees and Minutes is 9d. 40m. which added to the Latitude ſailed from, *viz.* 50d. 00m. the Sum 59d. 40m. is the Latitude come to, and AC 628 is the Diſtance required.

CASE

CASE IV. *Both Latitudes and Diſtance given, to find the Courſe and Difference of Longitude.*

A Ship in Latitude 50d. North, ſails 3505 Miles, and is then by Obſervation in Lat. 13d. 12m. I demand as above.

This Queſtion being larger than the Book can conveniently contain, if taken off the Meridian Line, I ſhall take it off a Scale of leſſer equal Parts, and find Meridional Difference of Latitude by the Table.

1. Draw ABD, upon which ſet off the proper Difference of Latitude 2208 from A to B, and the Meridional Difference of Latitude, 2676, from A to D. *Fig.* 30.

2. At B and D erect the Perpendiculars BC and DE.

3. With the Diſtance 3505, and one Foot in A, with the other croſs the Perpendicular BC, in C.

4. Draw AC continued to E, and 'tis done.

The Angle BAC meaſured on the Chords is 50d. 57m. and the Perpendicular D E 3298, is the Difference of Longitude required.

CASE V. *Both Latitudes and Departure given, to find Courſe, Diſtance, and Difference of Longitude.*

A Ship in Latitude 55d. North, ſails in the North East Quarter into Latitude 56d. 10m. North, her Departure 50 Miles; I demand as above.

This and all the following Queſtions in *Mercator's Sailing Geometrical* are too ſhort Diſtances to be taken off the Meridian Line, I ſhall therefore project them from larger equal Parts.

1. Draw ABD, upon which ſet off the proper Difference of Latitude 70 from A to B, and the Meridional Difference of Latitude 124 from A to D. *Fig.* 31.

2. From the Points B and D erect the Perpendiculars BC and DE.

3. Upon BC ſet off the Departure 50 from B to C.

4. Thro' the Point C draw the Line AC continued, till it cut the Perpendicular DE in E, and 'tis done.

Then the Angle at A meaſured on the Chords, is 35d. 32m for the Courſe, which is N. E. by N, ſomething Eaſterly, and the Hypotenuſe A C 86 is the Diſtance, and the Perpendicular D E 89 is the Difference of Longitude required.

CASE VI. *Both Latitudes and Difference of Longitude given, to find the reſt.*

Suppoſe two Places, one in Latitude 56d. 15m. and the other in Latitude 58d. 35m. their Difference of Longitude 2d. 30m. I demand the Courſe from the Southermoſt to the Northermoſt, and alſo their Diſtance and Departure.

1. Upon the Line ABD ſet off the proper Diff. Lat. and Merid. Diff. Lat. to B and D, and there erect
Fig. 32. Perpendiculars, as in Caſe the Fifth.

2. Upon D E ſet off the Difference of Longitude 150 from D to E.

3. From A to E draw the Hypotenuſe ACE to cut BC in C. Then is BC 80 the Departure; the Angle at A 29d. 53m. is the Courſe, and AC 161 is the Diſtance.

Note, The Figure placed between B and D (as here is 160) is the Meridional Difference of Latitude repreſented by the whole Line AD.

CASE VII. *One Latitude, Courſe and Departure given, to find the other Latitude, Diſtance and Diff. Longitude.*

A Ship in Latitude 48d. 0m. North, ſails S.S.W. ½ W. till her Departure be 60 Miles or Minutes; I demand as above.

1. Draw ABD at pleaſure.

2. At the Angle of 28d. 7m. the given Courſe,
Fig. 33. draw ACE continued.

3. At 60 Diſtance from ABD, draw the Parallel *e g*, and where it cuts A C E, as in C, let fall the Perpendicular CB.

4. Then is A B the proper Difference of Latitude, by which you may find the Latitude; Courſe, and alſo the Meridional Difference of Latitude, which (found as directed in *Mercator's Sailing Trigonometrical*, Caſe I.) is 306, which ſet from A to D.

5. Raiſe

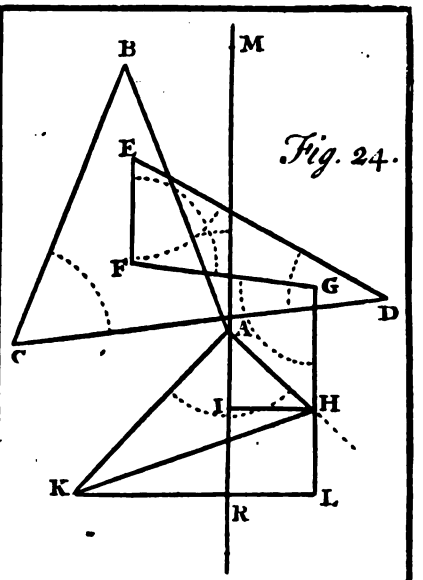


Fig. 24.

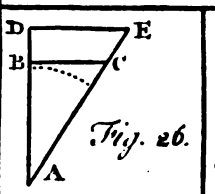


Fig. 26.

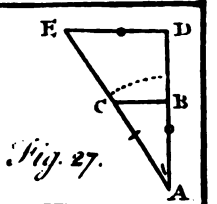


Fig. 27.

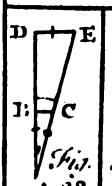


Fig. 28.

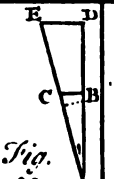


Fig. 29.

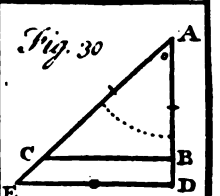


Fig. 30

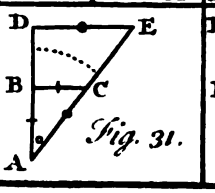


Fig. 31.

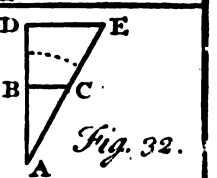


Fig. 32.

5. Raiſe the Perpendicular DE, to cut ACE in E, and 'tis done.

The Latitude come to is 56d. 8m. the Difference of Longitude D E 100, *&c.*

CASE VIII. *One Latitude, Diſtance, and Departure given, to find the other Latitude, Courſe, and Difference of Longitude.*

A Ship in Lat. 58d. 0m. North, ſails between the South and Weſt 127 Miles, her Departure 60; I demand the reſt.

See the Figure in Caſe the Seventh.

1. Draw A B D at pleaſure.

2. At 60 (the Departure) Diſtance from ABD, draw the Parallel *e g.*

3. With the Diſtance 127, and one Foot in A croſs the ſaid Parallel in C.

4. Let fall the Perpendicular CB to cut ABD in B; then is AB the proper Difference of Latitude, by which find the Meridional Difference of Latitude, as in Caſe VII. which ſet from A to D, and raiſe the Perpendicular DE.

5. From A through the Croſſing at C, draw ACE, to cut DE in E, and 'tis done.

The Latitude come to is 56d. 8m. the Angle A the Courſe 28d. 7m.

The Difference of Longitude D E is 110.

SECT. VIII.

Parallel Sailing Geometrical.

THERE are only two ways moſt uſeful and intelligible for laying down *Parallel Sailing*; the one called Bell-faſhion; the other Plane Triangle.

In the firſt of theſe it is laid down by a Figure ſomewhat like a Bell, from whence I ſuppoſe it takes its Name. In this Figure the two Sides A D and A E are equal (*viz.* equal to the Radius or *Fig.* 34.

Sine

Sine of 90; or if you think the Projection will be too ſmall, you may make them twice the Sine of 90, (provided you take all the other double alſo) and then the Line BC repreſents their true Diſtance in the Parallel, and DE repreſents their Diſtance in the Equinoctial, or Difference of Longitude.

The other Way is by Plane Triangle, in which two of the Angles are equal to the Complement of the
Fig. 35. Latitude in which their Diſtance is required; and therefore if their Difference of Longitude, or Diſtance in the Equinoctial, be given or required, the Triangle is right-angled, as in the Figure; and there the Angle at A is equal to the Complement of Latitude, the Perpendicular BC repreſents the Diſtance, and the Hypotenuſe AC the Difference of Longitude.

But when the Diſtance in one Parallel is given, and the Diſtance in another Parallel required, it makes an oblique Triangle, *viz.* with two acute Angles (becauſe the Complement of all Latitudes, except Latitude 0d. 0m. *viz.* under the Equinoctial, is leſs than 90 Degrees) as in the Fi-
gure, wherein the Angle at A repreſents the
Fig. 36. Complement of one Latitude, and its oppoſite Side BC their Diſtance in that Parallel, and the Angle at B is equal to the Complement of the other Latitude, and it's oppoſite Side AC repreſents their Diſtance in that Parallel, ſuppoſing each Ship keeps always under the ſame Meridian; and this by Oblique Triangles is uſeful only in the two laſt Caſes.

CASE I. *Two Ships or Places in one Parallel, their Latitude and Diſtance given, to find their Difference of Longitude.*

Two Ships in Lat. 50, diſtant 76 Miles; I demand as above.

1. With the Sine of 90 (or Chord of 60) and one Foot in A, ſweep the Arch DE.

Fig. 37. 2. With the Sine 40 (the Complement of Latitude) and one Foot in A, ſweep the Arch BC.

3. Take the Diſtance 76 from any equal Parts, and ſet from B to C, and draw the Line AE through the Point C, to cut the Arch DE in E, and draw AD through B.

4. Draw

4. Draw the Lines BC and DE, then is BC 76 the Diſtance, and DE 118 the Difference of Longitude.

The ſame Queſtion by Plane Triangle.

1. Draw the Line A B at Pleaſure. *Fig.* 38.

2. At an Angle of 40 Degrees the Complement of Latitude, draw the Hypotenuſe AC continued.

3. Draw the Parallel *e g* diſtant from AB, 76 the Diſtance.

4. Where that Parallel interſects the Hypotenuſe A C, as in the Point C, let fall the Perpendicular CB to cut AB in B, and 'tis done.

Then is B C the Diſtance 76, and AC 118 the Difference of Longitude.

CASE II. *Latitude and Difference of Longitude given, to find the Diſtance.*

Two Ships in Latitude 50, their Difference of Longitude 118: I demand their Diſtance,

See the Figures in Caſe I.

Bell-Faſhion.

1. With the Sine of 90 draw the Arch D E; and with the Sine of 40, the Complement of Latitude, draw the Arch B C, as in Caſe the firſt.

2. Set the Difference of Longitude 118, from D to E.

3. Draw the Lines A D and A E, which will cut the Arch B C in B and C.

4. Draw alſo the Lines BC and DE, and 'tis done.

The Line BC 76 is the Diſtance required.

By Plane Triangle.

1. Draw AB at Pleaſure.

2. With 40 Degrees, the Complement of Latitude, make the Angle at A, and draw the Hypotenuſe AC, upon which ſet off the Difference of Longitude 118 from A to C.

3. From C let fall the Perpendicular C B to cut A B in B, and 'tis done.

Then is B C 76 the Diſtance required.

CASE

CASE III. *Distance and Difference of Longitude given, to find the Course or Latitude.*

A Ship sails due W. 1200 Miles, her Difference of Longitude 4200 Miles. I demand what Latitude the Ship sails in.

1. With the Line of 90, and one Foot in A, draw the Arch D E.

2. Set the Difference of Longitude 4200 from Fig. 30. D to E, and draw the Line D E.

3. Draw the Lines A D and A E.

4. Reflect the Line D E to *n*, and draw A *n*.

5. Draw the Lines *i k* and *g h* parallel to A *n*, and distant from A *n* equal to half the given Distance 1350.

6. Where these Parallels cross the Lines A D and A E, there set the fine Point of your Compasses in A, draw the Arch B C, and then draw the Line B C.

Then place one Foot in A, and the other in B or C, that Extent applied to the natural Sines will reach to 40, the Complement of Latitude, so that 50 is the Latitude required.

2. *Plane Triangle.*

1. Draw A S indefinite.

2. At any where as at B, erect the Perpendicular Fig. 31. B C, and set off the Distance 1200 from B to C.

3. Take the Difference of Longitude 4200, and one Foot in the Line A S at A, and draw the Line A C.

4. With the Extent of 100, and one Foot in A draw the Arch *d e*.

The Angle at A measured on the Arch *d e*, is 40 Degrees, the Complement of Latitude required.

CASE IV. *Two Ships sailing directly North or South, their Distance and Difference given, to find their Distance asunder or Course.*

A Ship in the Lat. of 50 North, distant 200 Leagues North from another Ship in Latitude 53 North; what Distance asunder are they?

1. Find the Complement of the Latitude in which the Ships are, and the Complement of the other, and one Foot in A, describe

ſcribe the Arch DE, and upon that ſet off the Diſtance in that Parallel 200 from D to E.

2. With the Sine of 90 draw the Arch F G,

3. From A through D and E draw the Line A F and A G.

4. With the Sine Complement of the other Latitude, *viz.* 73 (which is the Sine of 17) and one Foot in A, draw the Arch BC to cut AF in B, and A G in C, and draw B C.

The Line BC meaſured on the ſame equal Parts from which you took the firſt Diſtance D E, will be found to be 91, the Diſtance of the Ships in Latitude 73; and if their Difference of Longitude were required, it may be found by meaſuring the Line F G.

By Plane Triangle.

Here is given the Angles A and B, the Complement of each Latitude, and the Side B C their Diſtance in Latitude 50, to find their Side A C, their Diſtance in Latitude 73: So that here is two Angles and a Side oppoſite to one of them given, to find the Side oppoſite to the other, by Caſe I. of *Oblique Plane Triangles*, to which I refer you. *Fig.* 42.

CASE V. *Two Ships in one Parallel with their Diſtance in that Parallel given, ſailing both directly North or South, and then their Diſtance in the Parallel come to be given, to find the Parallel come to.*

Two Ships in Latitude 50, diſtant 200 Miles, ſail North, till they are but 91 Miles diſtant; I demand the Latitude come to.

1. With Sine Complement of 50, and one Foot in A, draw the Arch D E, and ſet off 200 from D to E, being the given Diſtance in that Parallel. *Fig.* 43.

2. Through D from the Point A, draw the Line AF, and from A through E draw AG, having firſt drawn the Arch F G with the Sine of 90.

3. Biſect FG in *n*, and draw the Parallels *g h* and *i k*, diſtant from A *m* equal to half the Diſtance in the Latitude come to, *viz.* half 91, which is 45d. ½.

4. Ob-

4. Obſerve where theſe Parallels cut the Line AF and AG, as in B and C, therefore draw the Arch BC, and the Line BC, and 'tis done.

Then AB or AC, taken in your Compaſſes, and applied to the Sines, will reach to the Sine of 17, the Complement of the Latitude required; ſo that the Latitude come to is 73.

By Plane Triangle. See the Triangle in Caſe IV. in which there is given the Side BC 200, their Diſtance in Latitude 50, and the Angle oppoſite, *viz.* at A the Complement of that Latitude: There is alſo given the Side AC, their Diſtance in the Latitude come to, to find the Angle at B the Complement of the Latitude come to; ſo that here are two Sides and an Angle oppoſite to one of them given, to find the Angle oppoſite to the other by Caſe II. *Oblique Plane Trigonometry Geometrical.*

SECT. IX.

Middle Latitude Sailing Geometrical.

THERE are innumerable Ways of projecting *Middle Latitude Sailing.* I ſhall not trouble the Reader with them all, becauſe many of them are altogether uſeleſs and impracticable at Sea; I ſhall therefore only inſert thoſe Methods that may ſerve as a Demonſtration and Proof of the Proportions laid down in the Trigonometrical Part of *Middle Latitude Sailing*, and omit the reſt; being unwilling to put the Reader to the Charge of any Thing but what may be uſeful and profitable.

The firſt Proportion mentioned in *Middle Latitude Sailing Trigonometrical*, is, As Difference of Latitude to Difference of Longitude; ſo Sine Complement of Middle Latitude to the Tangent of the Courſe. Or (which is the ſame) As Difference of Latitude to Sine Complement of Middle Latitude; ſo Difference of Longitude to the Tangent of the Courſe.

The firſt Queſtion there, is in Caſe I. *One Latitude, Courſe,*

Courſe and Diſtance given, to find the other Latitude, Departure and Difference of Longitude.

A Ship in Latitude 50d. 0m. North, ſails N.E. by N. 987 Miles: I demand the Latitude come to, with Departure and Difference of Longitude.

Note; I ſhall inſtance, in this Queſtion, Examples of all the different Ways that I ſhall inſert for projecting *Middle Latitude Sailing*, and for demonſtrating the Proportions generally uſed therein, ſuppoſing it too tedious to inſert all the different Projections and Demonſtrations in every Caſe thereof, and firſt for the Proportion above mentioned.

Geometrical Conſtructions.

Draw the North and South Line A B, and with the given Courſe and Diſtance lay down the Triangle A B C, as in *Plane Sailing Geometrical*, *Fig.* 44. Caſe I. and having thus found the Difference of Latitude, and conſequently the Latitude come to, and Middle Latitude; ſet off the Sine of the Complement of Middle Latitude from A to *b*, and ſet off the Radius or Sine of 90, from A to *e*, and erect the Perpendiculars *b i* and *e g* parallel to BC, and continue BC at pleaſure: Then obſerve where the Hypotenuſe AC cuts the Perpendicular *e g* (which is erected from the Sine of 90) as is *k*; then take in your Compaſſes the Extent *e k*, and place from *b* to *i*, and from A through *i* draw the Line AD to cut the Perpendicular BD in D; then is BD 1003 the Difference of Longitude required, and BC 548 is the Departure, and AB 821 is the Difference of Latitude, the Hypotenuſe AC 987 the Diſtance, and the Angle BAC 33d. 45m. is the Courſe from the North Eaſtwards, or N.E. by N.

Now that this is a demonſtrative Proof of the Analogy or Proportion before mentioned, is evident; for as AB the Difference of Latitude to A *b* the Sine Complement of Middle Latitude, ſo is B D the Difference of Longitude to *b i*, which by Conſtruction is always equal to *e k*, the Tangent of the Courſe: And that it is, As A B to A *b*, ſo BD to *b i*, See *Euclid*, *Lib.* 6. *Prop.* 4. Therefore as Difference of Latitude to Sine Complement of Middle Latitude,

Latitude, ſo Difference of Longitude to Tangent of the Courſe.

Another Proportion is, as Sine Complement of Middle Latitude to Radius, ſo is Departure to the Difference of Longitude, which may eaſily be projected and demonſtrated in one Right-angled Triangle, to which if we affix another Right-angled Triangle; which is common in *Plane Sailing*, (*viz.* as Radius to the Diſtance, ſo is Sine of the Courſe to the Departure) making the Perpendicular, which is the Departure common to both, you will thereby have conſtituted an Oblique Triangle, whoſe Proportion between its oppoſite Sides and Angles plainly proves the third Proportion, *viz.* As Sine Complement of Middle Latitude to the Sine of the Courſe, ſo is the Diſtance of the Difference of Longitude: Or (which is the ſame) As Sine Complement of Middle Latitude to the Diſtauce, ſo is the Sine of the Courſe to the Difference of Longitude. I ſhall inſtance in the firſt Caſe before mentioned, where one Latitude, Courſe and Diſtance is given, to find the other Latitude, Departure and Difference of Longitude.

A Ship in Latitude 50d. 0m. ſails N.E. by N. 987 Miles; I demand as above.

With the Courſe 33d. 45m. and Diſtance 987, lay down the Triangle A B C, as in *Plane Sailing*, Caſe I. *Fig.* 45. and having found the Difference of Latitude, and conſequently Middle Latitude, which in this Queſtion is 56d. 51m. therefore draw the Line C D to make an Angle of 56d. 51m. with the Line CB, and draw the ſaid Line CD, till it cut the Line AB continued, then is CD 1003 the Difference of Longitude required. Becauſe if the Angle B C D be the Middle Latitude, the Angle BDC muſt needs be the Complement of Middle Latitude, becauſe D B C is a Right-Angle: And the Side BC being the Departure, is common to both Triangles; therefore as in the Triangle A B C, it is as Radius A B C to Diſtance AC, ſo is the Sine of the Courſe BAC to Departure B C; and then it muſt needs be alſo, As Sine of BDC, the Complement of Middle Latitude, to its oppoſite Side E C the Departure, ſo is Radius DBC to the Difference of Longitude D C. Here-

Hereby is alſo projected by Conſequence a Demonſtration of that Proportion, As Sine Complement of Middle Latitude to the Diſtance, ſo Sine of the Courſe to the Difference of Longitude: Or, as it is expreſſed in the Beginning of *Middle Latitude Sailing Trigonometrical*, as Sine Complement of Middle Latitude to the Sine of the Courſe, ſo is the Diſtance to the Difference of Longitude. For by theſe two Right-angled Triangles, with one Perpendicular common to both, is conſtituted the Oblique Triangle ACD, in which the Angle DAC is the Courſe, and its oppoſite Side DC is the Difference of Longitude, and the Angle ADC is Complement of Middle Latitude, and its oppoſite Side AC is the Diſtance; and hence it muſt needs follow by the known Proportion of Sides to their oppoſite Angles, and the contrary, that as Sine of ADC to AC, ſo Sine of DAC to DC: Therefore, as Sine Complement of Middle Latitude to the Diſtance, ſo Sine of the Courſe to Difference of Longitude.

These Methods of projecting Middle Latitude being the moſt demonſtrative Proofs of the Analogies or Proportions generally made Uſe of in the Trigonometrical or Arithmetical Calculation thereof, and therefore the moſt uſeful, I ſhall add one or two more, although there are almoſt infinite Methods for doing it; as one Way that is commonly uſed is by Semicircle, a Way very much in Practice, of which I ſhall inſtance in the foregoing Caſe. A Ship ſails from Lat. 50d. 0m. North, and ſails N. W. by N. 987 Miles; I demand the Latitude come to, with Departure and Difference of Longitude.

With the Chord of 60, and one Foot in H, draw the Semicircle AME, and at one End thereof, as at A, make an Angle of 33d. 4m. the Courſe given, and lay down the Triangle ABC, with the Courſe and Diſtance, as in *Plane Sailing*; and having found the Middle Latitude, which in this Queſtion is 56d. 51m. Set off the Chord thereof both Ways, from M to I and K, and draw I K to cut H M in L; then ſet the Diſtance L M from A to D, and from B to E, and continue the Line M H till it cut the Line A C, as in N; then from E erect the Perpendicular E G, and from D through N draw D G to cut E G in G; then is E G the Difference of Longitude, B C the Departure, A C the *Fig.* 46.

Diſtance A B the Difference of Latitude, and the Angle CAB the Courſe.

Another Projection of the ſame Queſtion.

With the given Courſe and Diſtance lay down the Triangle A B C, as in *Plane-Sailing*, *Caſe* I. and having found the Middle Latitude, as before, ſet off the Sine of the Complement of Middle Latitude upon the Line A B, from A to D, and ſweep the Arch D E, then with the Departure B C in your Compaſſes, and one Foot in D, extend the other along the Arch D E to E; and draw the Line D E equal to B C, and through E draw A E continued: and then with the Sine of 90, and one Foot in A, draw the Arch GH, till it cut the Line AE continued in H, and draw the Line GH, which meaſured on the ſame equal Parts from which the reſt were projected, and gives the Longitude required.

Fig. 47.

Theſe four Methods are ſufficient to entertain the Reader with Variety; and I ſuppoſe it altogether needleſs to inſtance in any more Caſes; it being very eaſy, from what is given in any other Caſe, whether both Latitudes and Courſe, or both Latitude and Difference of Longitude, *&c.* to make the ſame Projection, as a little Practice will make evident.

CHAP.

CHAP. II.

Navigation Trigonometrical.

SECT. I.

Plane Trigonometry.

IN the Solution of all Plane Triangles, whether right angled or oblique, there are always three Things given to find a fourth, ſuppoſing the Radius in right-angled Triangles to be always given or known; which three given Terms are always the firſt in the Proportion, and the required Term is always the fourth or laſt; and they are always to be placed in ſuch an Order, that the Proportion may be, as the firſt Term to the ſecond, ſo the third to the fourth. And before the admirable Invention of Logarithms, the Method was, as in other Caſes in the Rule of Three to multiply the two laſt Numbers by each other, and divide the Product by the firſt Number, and the Quotient was the Anſwer to the Queſtion; but by the Help of Logarithms the Work is much facilitated: For having ſet down the Numbers in their proper Order, and their Logarithms againſt them, as you ſee in the following Examples in *Plane Sailing*, you have no more to do, but add the two laſt Logarithms of the three that are given, and from their Sum ſubtract the firſt, the Remainder is the Logarithm of the fourth Number required. And again, obſerve in any three given Terms, where the Radius is the firſt Term, you need but add the two laſt together, and from the Sum abate one towards the Left-hand, and the Remainder is the Logarithm of the fourth Number required. But if Radius be the ſecond or third Term, place one on the Left-hand of the ſaid

third or ſecond Term, not Radius, and from that Sum ſubtract the firſt Term, the Remainder is the Logarithm of the fourth Term required. But if none of the Terms be Radius, as it frequently happens in Oblique Plane Triangles, but that every Term be the Logarithm, Sine or Tangent of ſome intermediate Degree or Number, then inſtead of the Logarithm of the firſt Term, whether Number, Sine, or Tangent, *&c.* take its Complement Arithmetical, which is done thus: Begin at the Left-hand, and ſubtract each Number from 9, and ſet down the Remainder, till you come at the Figure next the Right-hand, which ſubtract from 10, and ſet down the Remainder as before. This Number thus found is called the Complement Arithmetical of the Logarithm from whence it was taken, and is to be ſet down againſt the firſt Term, inſtead of the Logarithm itſelf, and the Logarithm of the ſecond and third Terms in their proper Order under it; which being done, add up all the three Sums together, and from their Sum ſubtract the Radius or 10 towards the Left-hand, the Remainder is the Logarithm of the fourth Term ſought.

Plane Trigonometry right-angled.

CASE I. *Hypotenuſe and one Acute Angle given (conſequently both) to find a Leg.* See *Plane Trigonometry Geometrical.* Caſe I.

Given { Hypotenuſe —— —— 550 } Required AB
{ The Angle at A — 35d. 0m. } and BC.

1. Making the Hypotenuſe the Radius, the Leg B C is the Sine of the Angle at A, and the Leg AB is the Sine Complement of the ſaid Angle by the Explanation of Axiom the firſt, therefore the Proportion is, as Radius to the Hypotenuſe, ſo the Sine Complement of the Angle at A, to the Leg A B.

Again, As the Radius to the Hypotenuſe, ſo the Sine of the Angle at A, to Leg B C.

2. Making the Baſe Radius, the Perpendicular B C is the Tangent of the Angle at the Baſe, and the Hypotenuſe the Secant of the ſaid Angle. By Explanation of Axiom the firſt, therefore the Proportion is, As the Secant

cant of the Angle at A to the Hypotenuſe, ſo is the Radius to the Leg A B.

Again, As the Secant of the Angle at A to the Hypotenuſe, ſo is the Tangent of the ſaid Angle at A to the Leg BC.

Note, Making the Perpendicular Radius, is the ſame as making the Baſe Radius, the Hypotenuſe ſtill continuing to be a Secant.

In this Part I have purpoſely omitted the Operations by Logarithms, they being inſerted at large in *Plane* and *Mercator's Sailing*, which is the Application of *Plane Trigonometry* to *Navigation*; but the Things given and required are the ſame in both. For whereas in *Caſe* I. of *Plane Trigonometry Right-angled*, there is given the Angles and Hypotenuſe to find a Leg, ſo in *Plane Sailing*, *Caſe* I. there is given the Courſe (which is the Angle at the Baſe) and conſequently its Complement (the other acute Angle) and the Diſtance (which is the Hypotenuſe) to find either Leg or both (which are Difference of Latitude and Departure) and the Rules for Circulation are the ſame.

CASE II. *Given the Angle at* A, *and a Leg* AB, *to find the Hypotenuſe.* See *Plane Trigonometry Geometrical*, Caſe II.

1. Making the Hypotenuſe Radius, the given Leg will be the Sine Complement of the Angle at A by the Explanation of Axiom the firſt; therefore, As Sine Complement of the Angle at A to the Baſe, ſo is Radius to the Hypotenuſe.

2. Making the Baſe Radius, the Hypotenuſe is Secant of the Angle at A; therefore, as Radius to the Baſe, ſo Secant of the Angle at A to the Hypotenuſe.

CASE III. *Given the Angles and a Leg, to find the other Leg. Given the Leg* AB, *as before; required the Leg* BC.

Note, Each Caſe here always refers to the ſame Caſe in *Plane Trigonometry Geometrical*, both in Right-angled and Oblique.

1. Making the Hypotenuſe Radius, the given Leg is Sine Complement of the Angle at A, and the required Leg BC is the Sine of the ſame Angle; therefore, as Sine Complement of the Angle at A to Leg AB, ſo Sine of the Angle at A to Leg BC.

2. Making the Baſe Radius, the Leg BC is the Tangent of the Angle at A; therefore, as Radius to the Leg BA, ſo Tangent of the Angle at A to the Leg BC.

Note, Both theſe Caſes, the ſecond and third, are contained in *Caſe* II. of *Plane Sailing*, where the Angles and a Leg (*viz.* Courſe and Difference of Latitude) are given, to find the Diſtance (which is the Hypotenuſe) by Caſe the ſecond, and the other Leg (which is the Departure) by Caſe the third. They are alſo both comprehended under the third Caſe of *Plane Sailing*, there being alſo the Angles and a Leg given, *viz.* Courſe and Departure, to find Diſtance and Difference of Latitude.

CASE IV. *Given the Hypotenuſe and a Leg, to find an Angle. Given Hypotenuſe* AC *and Leg* AB, *required* BAC.

1. Making the Hypotenuſe Radius, the Leg AB will be the Sine Complement of the required Angle, therefore, as Hypotenuſe to Radius, ſo Leg AB to Sine Complement of the Angle at A.

2. Making the Baſe Radius, the Hypotenuſe is the Secant of the Angle at A, therefore as the Baſe AB to Radius, ſo the Hypotenuſe AC to the Secant of the Angle at A.

CASE V. *Given the Hypotenuſe and a Leg, to find the other Leg. Given* AC *and* AB, *required* BC.

1. Making the Hypotenuſe Radius, the required Leg BC is the Sine of the Angle at A; therefore having found the Angle at A by Caſe the fourth, the Proportion is, as Radius to Hypotenuſe, ſo the Sine of the Angle at A to the Leg BC required.

2. Making the Baſe Radius, the required Leg BC is the Tangent of the Angle at A, therefore having found the Angle at A, as before, the Proportion is, as Radius to the Baſe, ſo Tangent of the Angle at A to Leg BC required.

Theſe

Theſe two Caſes are jointly comprehended in the fourth and fifth Caſes of *Plane Sailing*, in each of which there is given the Hypotenuſe and a Leg, to find the other Leg and the Angles.

Note, It is moſt uſual, in moſt Caſes in *Plane Sailing*, to work after the Method here delivered, making the Hypotenuſe Radius, becauſe that Way of ſtating brings it under that known Proportion of oppoſite Sides to oppoſite Angles.

CASE VI. *The Legs given to find the Angles. Given* B A *and* B C, *required* B A C.

Note, When a Side is required, any Side may be made Radius; but to find an Angle, a given Side muſt be made Radius; and here being obliged to find an Angle before we can find the Hypotenuſe, we ſhall make the Leg A B Radius, and then B C is the Tangent of the Angle at A. Therefore as A B to Radius, ſo B C to the Tangent of the Angle at A required.

CASE VII. *Given the Legs, to find the Hypotenuſe. Given* A B *and* B C, *to find* A C.

Firſt, Find the Angle at A as before, and then,

1. Making the Hypotenuſe Radius, the Baſe A B is the Sine Complement, and the Perpendicular B C is the Sine of the Angle at A; therefore, as Sine Complement of the Angle at A to the Baſe AB, ſo is the Radius to the Hypotenuſe AC required. Or, as Sine of the Angle at A to the Leg BC, ſo Radius to the Hypotenuſe required.

2. Making Baſe Radius, and having found the Angle at A, it is, as Radius to the Baſe, ſo the Secant of the Angle at A to the Hypotenuſe.

Theſe two Caſes are both contained under the ſixth Caſe of *Plane Sailing*; and if you carefully obſerve the Rules laid down in the Beginning of *Plane Sailing Geometrical*, about the Application of Plane Triangles to Queſtions in Navigation, the Connection between them will appear ſo plain, and the Directions given in one will be ſo plain and pertinent in the other, that there

needs no more to be ſaid to inſtruct the Reader as to the Solution of the Right-angled Plane Triangles.

SECT. II.

Of Oblique Plane Triangles.

I ſhall be a little more particular in this Section of Oblique Triangles, becauſe we have them not anſwered numerically elſewhere in this Book, except in ſome Queſtions at the latter End.

CASE I. *Two Angles and a Side oppoſite to one of them given, to find the Side oppoſite to the other.* Fig. 12.

Given { The Angle at A — 30d. 0m. / The Angle at B — 45d. 0m. / The Side B C — 490 } Required the Side A C.

By Axiom the Second.

As Sine of A	30d. 0m.	*Co. Ar.*	0.30103
To Side oppoſite B C	490		2.46239
So Sine of B	45 00		9.84948
To Side oppoſite A C required	410		2.61290

Note, Here being no Radius in this Proportion, I have taken the Complement Arithmetical of the firſt Logarithm, and added all the three Sums together, omitting one to the Left-Hand, according to the Directions in the Beginning hereof.

CASE

CASE II. *Two Sides and one Angle oppoſite to one of them given, to find the Side oppoſite to the other.* Fig. 13.

Given { The Side AB — 560 / The Side AC — 410 / The Angle B 35d. 0m. } Required the Angle at C.

By Axiom the Second.

				Co. Ar.
As Side AC	——	410	——	7.38722
To Sine of the Angle oppoſite	45	0	——	9.84948
So Side AB	——	560	——	2.74888
To Sine of the Angle oppoſite	74d.	58m.	—	9.98488

Note, This Anſwer is ambigious, and therefore it is neceſſary firſt to know whether the Angle ſought be acute or obtuſe, which if acute, it is 74d. 58m. but if obtuſe, it is found by ſubtracting 74d. 58m. from 180, the Remainder 105d. 2m. is the obtuſe Angle required.

CASE III. *Given two Sides, and an Angle oppoſite to one of them, to find the third Side* Fig. 13.

Given { The Side AB — 560 / The Side AC — 410 / The Angle at B 45d. 0m. } Required the Side BC.

Find the Angle at C, as in Caſe II. which, if ſuppoſed acute, is 74d. 58m. then the two Angles B and C being given, the third is found by Subtraction to be 60d. 0m. Then by Axiom the ſecond,

	d.	m.		*C. Ar.*
As the Sine of B	45	0	——	0.15051
To Side oppoſite A C		410	——	2.61278
So Sine of A	60	2	——	0.03767
To Side oppoſite		502	——	2.70097

But if the Angle at C had been ſuppoſed obtuſe, *viz.* 105d. 2m. the Angle at A would have been 29d. 58m. and then the Operation is,

As

	d.	m.		
As Sine of B —— ——	45	0	*Co. Ar.*	0.15052
To Side oppoſite A C — —		410	——	2.61278
To Sine of A —— ——	29	58	——	9.69853
To Side oppoſite B C ——		290	——	2.46183

CASE IV. *Given Two Sides and a continued Angle, to find either of the other Angles.* Fig. 14.

Given { The Side A C — 410, The Side A B — 560, The Angle A 30d. 0m. } Required the Angles B and C.

By Axiom the Third.

As Sum of the given Sides —	970	*Co. Ar.*	7.01323
To their Difference ——	150	——	2.17609
So Tangent of half Sum of unknown Angles ——	75d. 0m.	—	10.57194
To Tang. of half their Difference	29 59	—	9.76126

The Sum is the greater Angle C —— 104d. 59m.
So Difference is the leſſer Angle B —— 45 1

CASE V. *Two Sides and a contained Angle given, to find the third Side.* Fig. 15.

Given { The Side A C — 410, The Side A B — 560, The Angle A 30d. 0m. } Required the Side B C.

Find the Angle B by *Caſe* IV. *viz.* 45d. 1m. Then,

	d.	m.		
As the Sine of B ——	45	1	*Co. Ar.*	0.15039
To the Side oppoſite A C —		410	——	2.61278
So Sine of A —— ——	30	0	——	9.69897
To Side oppoſite B C ——		290	——	2.46214

CASE

CASE VI. *Three Sides given, to find an Angle.* Fig. 15.

Given { The Side A C 410 / The Side C B 290 / The Side A B 560 } Required the Angle at A.

Let fall a Perpendicular from C the greateſt Angle, upon AB the greateſt Side, by Axiom the Fouth.

		Co. Ar.
As the Baſe A B	560	7.25182
To the Sum of the Sides AC 410, and CB 290	700	2.84509
So the Difference of the ſaid Sides	120	2.07918
To the Difference of the Segments of the Baſe AD	150	2.17609

The half Difference 75, added to half the Baſe 280, the Sum 355 is the Baſe AE.

The half Difference 75, ſubtracted from half the Baſe 280, the Difference 205 is the Baſe EB.

Then in the Right-angled Triangle AEC is given AE 355, AC 410; to find the Angle A.

			Co. Ar.
As A C	410		2.61278
To Radius	90d.	0m.	10.00000
So AE	35	5	2.55022
To Sine Comp. of the Angle at A	30	1	9.93744

After the ſame Manner you may find the Angle E.

SECT. III.

Plane Sailing Trigonometrical.

ALthough the Method here propoſed be new and ſhort without the Trouble of Logarithms, Sines, Tangents and Secants; yet I ſhall by the Way ſet down an Example

Example or two in every Caſe, both in *Plane Sailing* and *Mercator*, according to the old and common Method, partly for the Help of thoſe, who either through Negligence, or Want of Opportunity to practiſe, have forgot at Sea what they have learned at School; but chiefly, that in all the Examples wrought by the new Way; I may refer to thoſe wrought by the old Way; that ſo the Reader ſeeing the exact Harmony and Concord which is between them, may (to his great Satisfaction) be convinced of the Verity and Infallibility of this new Method, equal to the beſt for Truth and Certainty, and ſuperior to all for Expedition and Readineſs.

Plane Sailing.

CASE I. *Courſe and Diſtance given, to find Difference of Latitude, and Departure.*

A Ship ſails N.W. by N. 123 Miles; I demand Difference of Latitude and Departure.

Firſt, for the Difference of Latitude.

	d.	m.	
As Radius — — —	90	00	— 10.00000
To the Diſtance ſailed — —		123	— 2.08990
So Sine Comp. of the Courſe —	56	15	— 9.91985
To the Difference of Latitude —		102½	— 2.00975

For the Departure.

	d.	m.	Co. Ar.
As Radius — — —	90	00	— 10.00000
To Diſtance ſailed — —		123	— 2.08990
To Sine of the Courſe — —	35	45	— 9.74474
To Departure — — —		68	— 1.83464

Example 2. A Ship ſails South 25 Degrees Eaſterly 96 Miles, I demand Difference of Latitude and Departure.

For

For the Difference of Longitude.

	d.	m.		
As Radius —— ——	90	00	—	10.00000
To Diſtance ſailed —— ——		96	—	1.98227
So Sine Comp. of Courſe ——	65	00	—	9.95728
To Diff. of Latitude —— ——		87	—	1.93955

For the Departure.

	d.	m.		
As Radius —— ——	90	00	—	10.00000
To Diſtance ſailed —— ——		96	—	1.98227
So Sine of the Courſe ——	25	00	—	9.62595
To Departure —— ——		40½	—	1.60822

CASE II. *Courſe and Difference of Latitude given, to find Diſtance and Departure.*

A Ship ſails S.W. by S. till her Difference of Latitude be 174 Miles; I demand her Diſtance and Departure.

For the Diſtance.

	d.	m.		
As Sine Comp. of Courſe ——	56	15	—	9.91985
To Difference of Latitude ——		174	—	2.24055
So Radius —— ——	90	00	—	10.00000
To the Diſtance —— ——		209	—	2.32070

For the Departure.

	d.	m.		
As Sine Comp. of Courſe ——	56	15	—	0.08015
To Difference of Latitude ——		174	—	2.24055
So Sine of the Courſe ——	33	45	—	9.74474
To Departure —— ——		116	—	2.06544

Example 2. A Ship ſails North 38 Degrees Weſterly, till ſhe raiſe the Pole 2 Degrees: I demand how far ſhe hath ſailed, and how much ſhe is departed from her firſt Meridian.

The 2 Degrees of Latitude reduced into Miles, is 120 Miles. Then for the Diſtance. A

	d.	m.		
As Sine Comp. of Courſe —	52	00	—	9.89653
To Difference of Latitude —		120	—	9.07018
So Radius — —	20	00	—	10.00000
To the Diſtance — —		152	—	2.18265

For the Departure.

	d.	m.		*Co. Ar.*
As Sine Comp. of Courſe —	52	00	—	0.10347
To Difference of Latitude —		120	—	2.07918
So Sine of the Courſe —	38	00	—	9.78934
To Departure — —		94	—	1.97199

CASE III. *Courſe and Departure given, to find Diſtance and Difference of Latitude.*

A Ship ſails S.E. by S. till her Departure be 103 Miles; I demand her Diſtance and Difference of Latitude.

For the Diſtance.

	d.	m.		
As Sine of the Courſe —	33	45	—	9.74474
To Departure — —		103	—	2.01284
So Radius — —	90	00	—	10.00000
To the Diſtance — —		185	—	2.26810

For the Difference of Latitude.

	d.	m.		*Co. Ar.*
As Sine of the Courſe —	33	45	—	0.25526
To Departure — —		103	—	2.01284
So Sine Comp. of Courſe —	56	15	—	0.91984
To Difference of Latitude —		154½	—	2.18794

Example 2. A Ship ſails North 19 Deg. 41 Min. Eaſterly, which is N.N.E. ½ Northerly, till her Departure be 72 Miles; her Diſtance and Difference of Latitude is required.

For

For the Diſtance.

	d.	m.		
As Sine of the Courſe ——	19	41	—	9.52739
To Departure —— ——		72	—	1.85733
So Radius —— ——	90	00	—	10.00000
To the Diſtance —— ——		214	—	2.32994

For the Difference of Latitude.

	d.	m.		
As Sine of the Courſe ——	19	41	—	0.47260
To Departure —— ——		72	—	1.85733
So Sine Comp. of Courſe ——	70	19	—	0.97385
To Difference of Latitude ——		201	—	2.30378

CASE V. *Diſtance and Difference of Latitude given, to find Courſe and Departure.*

A Ship ſails between the North and Eaſt 110 Miles, and then finds by Obſervation that ſhe hath raiſed the Pole one Degree; I demand the Courſe and Departure.

The Difference of Latitude reduced to Miles or Minutes is 60.

Then for the Courſe.

As the Diſtance —— ——		110	—	2.04139
To Radius —— ——	90d.	00m.	—	10.00000
So Difference of Latitude ——		60	—	1.77815
To Sine Comp. of Courſe —	56	57	—	9.73676

Which is N.E. by E. neareſt, or N.E. by E. 42 Min. Eaſterly.

For Departure.

	d.	m.		
As Radius —— ——	90	00	—	10.00000
To the Diſtance —— ——		110	—	2.04139
So Sine of Courſe —— ——	56	57	—	9.92334
To Departure —— ——		92	—	1.96473

Example

Example the Second.

A Ship ſails between the North and Eaſt, till her Difference of Latitude be 103 Miles, and then is diſtant from the Place ſhe ſail'd from 117 Miles, her Courſe and Departure is required.

For the Courſe.

As the Diſtance			117	2.06818
To Radius		90d.	00m.	10.00000
So Difference of Latitude			103	2.01284
To Sine Comp. Courſe	28	19		9.94466

For the Departure.

	d.	m.		
As Radius	90	00		10.00000
To the Diſtance			117	2.06818
So Sine of the Courſe	28	19		9.67609
To Departure			55½	1.74427

The Courſe is N.N.E. ſomewhat more than half a Point Eaſterly, and the Departure 55½ Miles.

CASE V. *Diſtance and Departure given, to find Courſe, and Difference of Latitude.*

A Ship ſails between the South and Weſt 124 Miles, her Departure 95 Miles: I demand the Courſe and Difference of Latitude.

For the Courſe.

As the Diſtance			124	2.09342
To Radius		90d.	00m.	10.00000
So Departure			95	1.97772
To Sine of the Courſe	50	00		9.88430

For

For the Difference of Longitude.

	d.	m.	
As Radius —— ——	90	00	— 10.00000
To the Diſtance —— ——		124	— 2.09342
So Sine Comp. of Courſe ——	40	00	— 9.80806
To Difference of the Latitude ——		80	— 1.90148

The Courſe is S.W. half Point Weſterly, or 4 ½ Points neareſt, the Difference of Latitude 80 Miles.

Example the Second.

A Ship ſails North Eaſterly 100 Miles; till her Departure be 38 Miles, her Courſe and Difference of Latitude is required.

For the Courſe.

As the Diſtance —— ——	100		— 2.00000
To Radius —— ——	90d.	00m.	— 10.00000
So the Departure —— ——	38		— 1.57978
To Sine of the Courſe ——	22	20	— 9.57978

For the Difference of Latitude.

As Radius —— ——	90d.	00m.	— 10.00000
To the Diſtance —— ——	100		— 2.00000
So Sine Comp. of Courſe ——	67	40	— 9.96613
To Difference of Latitude ——	— 92 ½		— 1.96613

The Courſe N.N.E. *fere*; and the Difference of Latitude 92 ½.

CASE VI. *Difference of Latitude and Departure given, to find Courſe and Diſtance*

A Ship ſails between the North and Weſt, till her Difference of Latitude be 200 Min. and Departure 108 Min. or Miles; I demand the Courſe and Diſtance.

For the Courſe.

As Difference of Latitude	220	2.34242
To Radius	90d. 00m.	10.00000
So Departure	108	2.03342
To Tangent of the Courſe — 26	9	9.69100

For the Diſtance.

As Sine of the Courſe	26d. 9m.	9.64416
To Departure	108	2.03342
So Radius	90 00	10.00000
To the Diſtance	245	2.38926

The Courſe N.N.W. ſomewhat more than ½ Weſterly, the Diſtance 245 Miles.

Example the Second.

A Ship ſails between the South and Weſt, until her Difference of Latitude be 309 Min. and Departure 206 Min. I demand the Courſe and Diſtance.

For the Courſe.

As Diff. of Latitude	309	2.48995
To Radius	90d. 00m.	10.00000
To Departure	206	2.31386
To Tangent of the Courſe — 33	41	9.82391

For the Diſtance.

As Sine of the Courſe —	33d. 41m.	9.74398
To the Departure	206	2.31386
So Radius	90 00	10.00000
To the Diſtance —	371	2.56988

The

The Courſe S.W. by S. *fere*, the Diſtance 371 Miles.

Thus have I ſet down two Examples in every Caſe of Plane Sailing, according to the old and common Way of working by Logarithms, Sines, and Tangents, having obſerved in the three firſt Caſes where the Courſe is given, to ſet one Queſtion with the Courſe given in Points of the Compaſs at N.N.W. *&c.* and another with the Courſe given in Degrees, as South 25 Degrees Eaſterly, *&c.* intending in the Sequel hereof, to proceed to ſhew the Reader how to anſwer all the ſame Queſtions, (where the Courſe is either given or required) in Points, Half-points, or Quarter-points of the Compaſs, without any Canon, Scale or Compaſſes, only by two Tables, each of which (or both if Need require) might be contain'd in one Page hereof; which Table you have at the Beginning of the ſecond Part of this Book; by which Tables only you may work all the Caſes in Plane Sailing, and keep a Journal by that Way, without a Traverſe Table, or the voluminous Tables of Logarithms, Sines, Tangents, *&c.* which fill up the far greater Part of ſome of our Epitomies of Navigation now in Print: You may alſo by the ſame, and a Table of Meridional Parts, work all the Caſes in *Mercator*; and keep a Reckoning throughout all the World; and not only ſo, but that the Work may juſtly deſerve the Title of a New Method, I ſhall add ſome Rules teaching how to work any Queſtion in Plane Trigonometry, or Navigation, only by the Pen or a Piece of Chalk, without any Geometrical Projection by Scale and Compaſſes, or Arithmetical Calculation by Sines and Tangents; ſo that if at Sea you have loſt all Books and Inſtruments, or if a Shore you be in Company where you have no Books nor Inſtruments preſent, you ſhall work any Queſtion as eaſily as a Queſtion in Common Arithmetic, a Thing never yet known, nor publiſh'd by any: But I ſhall now proceed to propoſe an Example, or two, in the ſeveral Caſes of,

SECT. IV.

Mercator's *Sailing Trigonometrical.*

CASE I. *One Latitude, Courſe and Diſtance given, to find the other Latitude, and Difference of Longitude.*

IN this, and the other Caſes, we ſhall have Occaſion to make Uſe of the Meridional Difference of Latitude; for the finding of which, obſerve, if two Places (whoſe Meridional Difference of Latitude you ſeek) be both in North Latitude, or both in South Latitude, ſubtract the Meridional Parts of the leſſer Latitude, from the Meridional Parts of the greater Latitude, the Remainder is the Meridional Difference of Latitude; but if one be in North Latitude, and the other in South, add the Meridional Parts of both Latitudes together, the Sum is the Meridional Difference of Latitude; the following Examples will make it plain.

A Ship in Latitude of 50d. 00m. North, ſails N.W. by N. 987 Miles; I demand the Latitude come to, as alſo the Difference of Longitude.

As Radius ——	—— 90d. 00m.	——	10.00000
To the Diſtance ——	—— 987	——	2.99432
So Sine Compl. of Courſe —	56 15	——	9.91984
To proper Diff. of Lat. ——	820	——	2.91416

The Difference of Latitude 820 min. divided by 60, to bring it into Degrees, is 13d. 40m. which added to 50 Deg. (becauſe the Ship ſails towards the Pole, and increaſes her Latitude) the Sum 63d. 40m. is the Latitude come to. Then to find the Meridional Difference of Latitude between Lat. 63d. 40m. and Lat. 50d.

Meridional

Meridional Parts for Lat. 63d. 40m. —— —— 4994
Meridional Parts for Lat. 50 00 —— —— 3475

Subt. one from t'other, reſt Merid. Diff. Lat. —— 1519

Then for the Difference of Longitude.

	d.	m.	
As Radius —— ——	90	00	— 10.00000
To Merid. Diff. of Latitude —	1519		— 3.18155
So Tangent of the Courſe ——	33	45	— 9.82489
To Difference of Longitude ——	1015		— 3.00644

The Latitude come to is 63d. 40m. and Diff. Longitude 1015m. which divided by 60, is 16d. 55m. Weſt Longitude, becauſe the Courſe is Weſterly.

CASE II. *Both Latitudes and Courſe given, to find the Diſtance and Difference of Longitude.*

A Ship ſails from St. *Abb's-Head*, in Latitude 56d. 25m. N. and ſails away N.N.E. ſeveral Days, and then finds herſelf by Obſervation to be in Latitude 68d. 30m. I demand how far ſhe hath ſailed, and what is her Difference of Longitude.

	d.	m.	
Meridional Parts for —— —	68	30	—— 5712
Meridional Parts for —— ——	56	25	—— 4119
Meridional Difference of Lat. ——			—— 1593
Proper Difference of Latitude —	12	05, or	—— 725

Then for the Diſtance.

	d.	m.	
As Sine Comp. of Courſe ——	22	30	—— 9.96561
To proper Diff. of Latitude ——	725		—— 2.86033
So Radius —— —— —	93	00	—— 10.00000
To the Diſtance — — —	785		—— 2.89472

For the Difference of Longitude.

	d.	m.	
As Radius ——— ———	90	00	— 10.00000
To Meridian Diff. Latitude —	1593		— 3.20221
So Tangent of the Courſe —	22	30	— 9.61722
To Diff. of Longitude ———	660		— 2.81943

The Diſtance is 785 Miles, or 262 Leagues almoſt, and the Difference of Longitude is 660 Min. or 11 Degrees Eaſt from St. *Abb's-Head*, which added to 14d. 12m. the Longitude of St. *Abb's-Head*, (accounting from *Pico Teneriff*) the Sum 27d. 12m. is the Longitude the Ship is in, which being found, find in a Mercator's Chart the Longitude ſo found, and the Latitude by Obſervation 68d. 30m. and that is the Point in the Chart that your Ship is in: If you reckon your Longitude from *London*, as is commonly done, the Rule is the ſame.

CASE III. *One Latitude, Courſe, and Difference of Longitude given, to find the other Latitude, and Diſtance.*

A Ship in Latitude 50, ſails N.N.W. till her Difference of Longitude be 7 Degrees, or 420 Min. I demand the other Latitude and Diſtance.

For the other Latitude.

	d.	m.	
As Tangent of the Courſe —	22	30	— 9.61722
To Difference of Longitude —	420		— 2.62324
So Radius ——— ———	90	00	— 10.00000
To Meridian Diff. Latitude —	1014		— 3.00602
Merid. Parts anſwering to Latitude 50d. com.			— 3475
To which add Meridional Diff. Lat. ———			— 1014
The Sum ——— ——— ———			— 4489

Which found in the Table of Meridional Parts, anſwers to 59d. 40 m. the Latitude come to. *Then*

Then for the Diſtance.

	d.	m.		
As Sine Comp. of Courſe ———	67	30	--	9.96561
To proper Diff. of Latitude —		580	—	2.76343
So Radius ——— ———	90	00	—	10.00000
To the Diſtance ——— ———		628	—	2.79782

The Latitude come into is 59d. 40m. the Diſtance 628 Miles.

CASE IV. *Both Latitudes and Diſtance given, to find the Courſe and Difference of Longitude.*

A Ship in Latitude 50d. 00m. N. ſails 3505 Miles, and then is found by Obſervation to be in Latitude 13d. 12m. North, I demand her Courſe, and Difference of Longitude.

The proper Difference of Latitude is found by ſubtracting the leſſer Latitude from the greater, the Remainder is the Difference of Latitude in Degrees and Minutes, which multiplied by 60, gives the Difference of Latitude in Miles.

Example.

Greater Latitude—	50d.	00m.	36	48
Leſſer Latitude —	13	12	60	
Remains ———	36	48	2208	proper Diff. Lat.

	d.	m.		
Meridional Parts for Latitude ——	50	00	———	3475
Meridional Parts for Latitude ——	13	12	———	799
Meridional Difference of Lat. ———			———	2676
Proper Difference of Latitude ———			———	2208

For the Courſe.

To the Diſtance		3505	3.54469
To Radius	90	00	10.00000
So proper Diff. of Lat.		2208	3.34400
To Sine Comp. of Courſe	50	57	9.79931

For the Difference of Longitude.

	d.	m.	
As Radius	90	00	10.00000
To the Meridional Diff. of Lat.		2676	3.42749
So Tangent of the Courſe	50	57	10.09086
To Diff. of Longitude		3298	3.51835

In the four foregoing Caſes I have purpoſely omitted the Canons for finding the Departure, it being ſufficiently taught in the Caſes of Plane-Sailing; and the Canons for finding it are exactly the ſame in both, according to what is given. Nevertheleſs in all the following Caſes (except the 6th) the Departure is given, and therefore I ſhall make it one neceſſary Term in each of the enſuing Caſes: And when we come to the Practical Part, *viz.* the keeping of a Journal, I ſhall lay down ſome eaſy and compendious Ways for reducing Departure to Difference of Longitude, both by Mercator and Middle Latitude, without any Canon.

CASE V. *Both Latitudes and Departure given, to find Courſe, Diſtance, and Difference of Longitude.*

A Ship ſails from Latitude 55d. 00m. N. and ſails between the North and Eaſt into Latitude 56d. 10m. N. her Departure 50 Min. or Miles; I demand the Courſe ſteered, the Diſtance ſail'd and the Difference of Longitude.

For

For the Courſe.

As proper Diff. of Latitude		70	—	1.84509
To Radius		90 00	—	10.00000
So Departure		50	—	1.69897
To Tang. of the Courſe		35 32	—	9.85388

For the Diſtance.

		d.	m.		
As Sine of the Courſe		35	32	—	9.76430
To Departure			50	—	1.69897
So Radius		90	00	—	10.00000
To the Diſtance			86	—	1.93467

For the Difference of Longitude.

As Radius	90	00	—	10.00000
To Meridional Diff. of Lat.		124	—	2.09342
So Tangent of the Courſe	35	32	—	9.85380
To Difference of Longitude		89 *fere*	—	1.94722

Or, which is the ſame.

As proper Difference of Latitude	70	*Co. Ar.*	8.15499
To Meridional Difference of Lat.	124		2.09342
So Departure	50		1.69897
To Difference of Longitude	89 *fere*		1.94738

CASE VI. *Both Latitudes, and Difference of Longitude given, to find Courſe, Diſtance and Departure.*

Suppoſe two Places, one in Latitude 56d. 15m. North, the other in Latitude 58d. 35m. North, their Difference of Longitude 2d. 30m. I demand the Courſe and Diſtance from the Southermoſt to the Northermoſt, and alſo the Departure.

Proper Difference of Latitude	140
Meridian Difference of Latitude	260

For

For the Courſe.

As Merid. Diff. Lat.	260		2.41664
To Radius	90	0m.	10.00000
So Diff. Long.	150		2.17609
To Tang. Courſe	29	53	9.75945

For the Diſtance.

As Sine Comp. of Courſe	29	53	9.93804
To proper Diff. Lat.	140m.		2.14612
So Radius	90	00	10.00000
To the Diſtance		161	2.20808

For the Departure.

As Sine Comp. Courſe	29	53 *Co. Ar.*	0.06196
To proper Diff. Lat.	140		2.14612
So Sine of Courſe	29	53	0.00743
To Departure		80	1.90551

Or, as Radius to proper Difference of Latitude, ſo Tangent of the Courſe to Departure.

CASE VII. *One Latitude, Courſe and Departure given, to find the other Latitude, Diſtance and Difference of Longitude.*

A Ship in Latitude 58d. 00m. N. ſails S.S.W. half W. till her Departure be 60 min. I demand the Latitude come to, Diſtance ſail'd, and Difference of Longitude.

☞ If your Difference of Longitude be Eaſt, add it to, or if Weſt, ſubtract it from the Longitude ſailed from, and the Sum or Remainder is the Longitude come into, if you begin to reckon your Longitude from *Pico Teneriff*, (which is ſeldom done) but if you begin your Longitude at the Place ſailed from, (according to the *Mariner's Compaſs Rectified*) you only reckon your Longitude Eaſt or Weſt, according to the Denomination of your Departure, whether Eaſt or Weſt.

For

For the Difference of Latitude.

	d.	m.	*Co. Ar.*
As Sine of the Courſe	28	07	0.32673
To the Departure		60	1.77815
So Sine Comp. of Courſe	61	53	9.94546
To Difference of Latitude		112	2.05034

Difference of Latitude 112 Miles, or Minutes; or, 1d. 52m. which ſubtracted from the Latitude ſailed from, 58 Deg. (becauſe the Courſe is Southerly) the Remainder 5od. 8m. is the Latitude come to.

Then for the Diſtance.

	d.	m.	
As Sine of the Courſe	28	07	9.67326
To Departure		60	1.77815
So Radius	90	00	10.00000
To the Diſtance		127	2.10489

For the Difference of Longitude.

	d.	m.	
As Radius	90	00	10.00000
To Meridional Diff. of Lat.		206	2.31386
So Tangent of the Courſe	28	07	9.72780
To Difference of Longitude		110	2.04166

Or, Difference of Longitude may be thus found.

			Co. Ar.
As proper Difference of Lat.			7.94965
To Meridional Diff. Lat.		206	2.31386
So Departure		60	1.77815
To Difference of Longitude		110	2.04166

CASE

CASE VIII. *One Latitude, Diſtance and Departure given, to find the other Latitude, Courſe and Difference of Longitude.*

A Ship in Lat. 58d. om. N ſails between the South and Weſt 127 Miles, and then finds her Departure to be 1 Degree, or 60 Minutes; I demand as above.

For the Courſe.

As the Diſtance		127		2.10380
To Radius		90 00		10.00000
So Departure		60		1.77815
To Sine of the Courſe	28	11		9.67435

For the Difference of Latitude.

	d.	m.		*Co. Ar.*
As Sine of the Courſe	28	11		0.32564
To Departure		60		1.77815
So Sine Comp. of the Courſe	61	49		9.94519
To Difference of Latitude		112		2.04898

For the Difference of Longitude.

	d.	m.		
As Radius	90	00		10.00000
To Meridional Diff. of Lat.		206		2.31386
So Tangent of the Courſe	28	11		0.72001
To Difference of Longitude		110		2.04287

The Difference of Latitude is 112 Minutes; or 1 Degree 52 Minutes, which ſubtracted from the Latitude ſailed from 58 Deg. the Remainder 56 Deg. 8 Min. is the Latitude come to; and the Difference of Longitude is 110 Minutes, or 1d. 50m. which is to be ſubtracted from the Longitude ſailed from, if you are decreaſing your Longitude, &c.

How

How to work a Mercator's Sailing, without a Table of Meridional Parts.

The Table of Meridional Parts may be ſupplied by the Table of Artificial Tangents; for every half Degree of the Tangents above 45 Anſwers to one Degree of Latitude, (the Characteriſtic or Index of the Tangent being rejected) and therefore to find the Meridional Leagues for any Latitude, and half the given Latitude to 45, the Sum is a Degree, whoſe Tangent multiplied by 10, and the Product divided by 376, the Quotient is the Meridional Leagues belonging to that Latitude, which multiplied by 3, gives (nearly) the Meridional Parts found in the Table.

Note, If you have a Table that hath 6 Figures, or more, in the Tangents, beſides the Index, you may uſe the firſt ſix Figures, and need not multiply them by 10, as before.

But becauſe this Way is not of Uſe, except when both Latitudes are given or found, to find the Difference of Longitude, 'tis beſt to find the Tangents anſwering to both Latitudes, and ſubtract the leſs from the greater, and divide the Remainder 376, which gives the Meridional Difference of Latitude in Leagues, which if you pleaſe you may reduce to Miles, (by multiplying by 3) without further Trouble.

Exemplr.

In the foregoing Queſtion in the Eight Caſe of Mercator's Sailing Trigonometrical, the two Latitudes are found to be 58d. 0m. and 56d. 8m.

Half of 58d. 0m. is 29d. 0m.
To which add — 35 0

The Sum is —— 74 0 whoſe Tangent is 542503

Half of 56d. 8m. is 28 4
To which add —— 45 0

The Sum is —— 73 4 whoſe Tangent is 516471
Remainder —— 26032

376)

376)26032(69 Merid. Diff. Lat. in Leagues —— 69
3472 Which multiply by —— — 3

··88 Gives Merid. Diff. Lat. in Miles — 207

Nearly agreeing with that found by the Table.

And altho' this be not exactly the ſame with the Table, yet the Difference is ſcarce diſcernable, and therefore it may be of great Uſe where Tables of Meridional Parts are wanting.

SECT. V.

Parallel Sailing Trigonometrical.

SOME rank the Caſes of *Parallel Sailing* amongſt the reſt of the Caſes in *Mercator's Sailing*; and indeed not without good Reaſon, ſeeing it is grounded upon the ſame Projection, and is really a Branch of the ſame. Nevertheleſs, ſeeing both *Data* and *Quæſita* relate only to the Diſtance or Difference of Longitude, *&c.* of Ships or Places in the ſame Parallel or Latitude: I chuſe rather to ſpeak of it in ſo many diſtinct Caſes under that Head, and ſhall (as before) ſet down an Example in every Caſe, and work it the common Way, (*viz.* by Logarithms, *&c.*) here, and ſhall hereafter proceed to work it alſo, as well as *Plane* and *Mercator's*, without any Canon, only by common Arithmetic.

CASE I. *Two Ships (or Places) in one Parallel, their Latitude and Diſtance given, to find their Difference of Longitude.*

Suppoſe two Ships in Latitude 50d. 00m. diſtant 76 Miles; I demand their Difference of Longitude.

As

	d.	m.	
As Sine Comp. of Latitude —	50	00	9.80807
To Radius —— ——	90	00	10.00000
So Diſtance —— ——		76	1.88081
To Difference of Longitude —		118	2.07274

The Difference of Longitude 118m. or 1d. 58m.

CASE II. *Two Places in one Parallel, their Latitude and Difference of Longitude given, to find their Diſtance.*

This is only the former Canon inverted, as in the following Example.

The Latitude of two Ships (or Places) and their Difference of Longitude given, to find their Diſtance.

Example. Suppoſe two Places in the Latitude of 50d. 0m. their Difference of Longitude 118m. I demand their Diſtance.

The Difference of Longitude is 118 Min.

	d.	m.	
As Radius —— ——	90	00	10.00000
To Sine Comp. Lat. ——	50	00	9.80806
So Difference of Longitude —		118	2.07188
To the Diſtance —— ——		76	1.87994

CASE III. *Two Places in one Latitude, their Diſtance and Difference of Longitude given, to find the Latitude they are in.*

Example. A Ship ſails due Weſt 2700 Miles, and then finds her Difference of Longitude to be 4200 min. I demand what Latitude the Ship ſails in.

As Diff. Longitude ——	4200		3.62325
To Radius —— ——	90d.	0m.	10.00000
So is the Diſtance ——	2700		3.43136
To Sine Comp. Lat. ——	50.00		9.80811

CASE

CASE IV. *Two Ships ſailing directly North or South, their Diſtance in one Parallel given, to find their Diſtance in another Parallel.*

Example. Suppoſe two Ships in Latitude 50d. 00m. North, diſtant 200 Miles, ſail both directly North into Latitude 73d. 00m. I demand their Diſtance in that Parallel.

	d.	m.	
As Sine Comp. of Lat. ſailed from	50	00	*Co. Ar.* 0.19194
To their Diſtance in that Parallel		200	—— 2.30103
So Sine Comp. of Lat. ſail'd to —	73	00	—— 9.46593
To their Diſtance of Lat. ſail'd to —		91	—— 1.95890

CASE V. *Two Ships in one Parallel, with their Diſtance in that Parallel given, ſailing both directly North or South, with their Diſtance in the Parallel ſail'd to given, to find the Latitude come to.*

Example. Two Ships in Latitude 50d. 00m. diſtant 200 Miles, ſail both directly North, till their Diſtance is but 91 Miles; I demand the Latitude come to.

This is but the laſt Canon inverted, *viz.*

			Co. Ar.
As their Diſtance in Lat. ſail'd from —		200	—— 7.69897
To Sine Comp. of Lat. ſail'd from	50d.	00m.	— 9.80807
So Diſtance in Lat. come to		91	—— 1.95904
To Sine Comp. of Lat. come to —	73	00	—— 9.46608

In theſe five Caſes of *Parallel Sailing*, I have ſet down but one Example in each Caſe, it being of no great Uſe in the Practice of Navigation; and yet it was not fit it ſhould be omitted, becauſe of its Uſefulneſs, as being a good Help towards a right Notion and Apprehenſion of the Terreſtial Globe; for in *Plane Sailing* there is no ſuch Thing as Difference of Longitude, as diſtinct from Depar-

Departure; but here the Difference between the one and the other is plainly evident, the Difference of Longitude being ſometimes twice or thrice as much as the Departure, it bearing always to the ſame Proportion to the Departure, as Radius doth to Sine Complement of the Latitude or Parallel ſailed in.

SECT. VI.

Middle Latitude Sailing Trigonometrical.

ALtho' *Middle Latitude Sailing* is not exactly true, yet becauſe of it's (general) Conformity to the Globe, I ſhall not altogether omit it; for not withſtanding it comes ſhort of *Mercator*'s (or rather *Wright*'s) Sailing, (in which the Degrees of Longitude bear exactly the ſame Proportion to the Degrees of Latitude in any Parallel, as it doth upon the Globe) yet it exceeds *Plane Sailing* (which ſuppoſeth the Earth to be a plane Superficies, and the Degrees of Longitude and Latitude to be every where equal;) and therefore ſeeing it hath been ſometimes taught and practiſed, as one of the Kinds of Sailing (or keeping a Reckoning) now in Uſe; I ſhall proceed to an Example in each Caſe thereof. And the rather I take Notice of it, becauſe when I come to go over this in the new Way of Working without any Canon, I ſhall ſhew how it may be done, not only with more Eaſe and Expedition, but alſo much more nearly (if not exactly) agreeing with *Mercator*, and conſequently with the Globe itſelf, than what has been commonly taught and practiſed in that Kind of Sailing; but ſhall refer that to its proper Place in the Second Part hereof, and ſhall here proceed in (as in *Plane* and *Mercator*, *&c.*) to work the ſeveral Caſes of *Middle Latitude Sailing* the common Way, and the Analogies or Proportions made Uſe of herein, beſides thoſe taught in *Plane Sailing*, which

are applicable and uſeful here, as well as in *Mercator's Sailing*) are commonly theſe two, *viz.*

As Difference of Latitude
To Difference of Longitude,
So Sine Complement of Middle Latitude
To Tangent of the Courſe from the Meridian.

The other Proportion is,

As Sine Complement of Middle Latitude
To Radius,
So is the Departure
To Difference of Longitude.

And theſe Proportions may be inverted according to what is given, and what is required, by *Euclid. Lib.* 5. *Prop.* 14. & 16. & *Corol.* always obſerving to make the required Term the laſt of the Four in the Proportion; As Suppoſe both Latitudes and Courſe be given, and Difference of Longitude required, then the Proportion will be,

As Sine Complement of Middle Latitude
To Tangent of the Courſe,
So Difference of Latitude
To Difference of Longitude.

And ſo in others, as in the enſuing Operations will more plainly appear.

There is alſo another Proportion of Uſe for finding the Courſe, Diſtance, or Difference of Longitude, when any two of them, together with both Latitudes, are given or found; and the Proportion is,

As Sine Complement of Middle Latitude
Is to the Sine of the Courſe from the Meridian,
So is the Diſtance ſailed
To the Difference of Longitude.

And

And ſo by inverting the Canon, any three of them being given, the fourth may be found.

CASE I. *One Latitude, Courſe, and Diſtance given, to find the other Latitude, Departure and Difference of Longitude.*

A Ship in Latitude 50d. 00m. North, ſails N.W. by N. 987 Miles: I demand the Latitude come to, with the Departure and Difference of Longitude.

See the ſame Queſtion in *Mercator's Sailing*, *Caſe* the firſt.

For the Difference of Latitude.

	d.	m.		
As Radius —— ——	90	00	—	10.00000
To the Diſtance —— ——		987	—	2.99432
So Sine Comp. of Courſe ——	56	15	—	9.91984
To Difference of Latitude ——		821	—	2.91416

The Latitude come to is 63 deg. 41 min.

For the Departure.

	d.	m.		
As Radius —— —— ——	90	00	—	10.00000
To the Diſtance —— ——		987	—	2.99432
So Sine of Courſe —— ——	33	45	—	9.74473
To Departure —— ——		548	—	2.73905

For the Difference of Longitude.

Becauſe this Canon for finding the Difference of Longitude is grounded upon the Middle Latitude, obſerve that it is always found by adding the two Latitudes together, and half the Sum is the Middle Latitude required.

	d.	m.
Thus is the Example the Latitude ſailed from —	50	00
The Latitude ſailed to is —— —— ——	63	41
The Sum is —— —— —— ——	113	41
The Half of which is the Middle Latitude, *viz.*—	56	51

The exact Half is 56d. 50m. ½; but you need not be careful to a half Minute; but where the Sum is an odd Minute, take always the bigger Half, for the Middle Latitude is a Latitude rather too little to work with, and conſequently the Sine Complement of it is always a Sine rather too great, and makes the Longitude come out leſs than really it ſhould be: And although there is no Way to find a Mean Latitude to work with as Middle Latitude (without too much Trouble) that will bring out the required Longitude the ſame exactly with *Mercator*; yet the Middle Latitude found as before, being always too little, the taking the greater Half, where an odd Minute happens, will be ſo far from augmenting the Error, that it rather leſſens it, and makes the Longitude ſo found more nearly (though not exactly) conformable to the Longitude found by *Mercator's Sailing*; which for Inſtance in this firſt Queſtion, we ſhall work by each of the three Canons before-mentioned.

	d.	m.		*Co. Ar.*
As Sine Comp. of Mid. Lat.——	56	51	—	0.26215
To Tang. of the Courſe ——	33	45	—	9.82489
So Diff. of Latitude — ——		821	—	2.91434
To Diff. of Longitude—— ——		1003	—	3.00138

Again,	d.	m.		
As Sine Comp. of Mid. Lat.——	56	51	—	9.73785
To Radius— —— ——	90	00	—	10.00000
So Departure —— ——		548	—	2.73878
To Difference of Longitude ——		1003	—	3.00093

Again,

Again,	d.	m.		*Co. Ar.*
As Sine Comp. of Mid. Lat. ——	56	51	—	0.26215
To Sine of Course — ——	33	45	—	9.74473
So is the Distance— — ——		987	—	2.99432
To Difference of Longitude ——		1003	—	3.00120

CASE II. *Both Latitudes and Course given, to find Distance, Departure, and Difference of Longitude.*

A Ship takes her Departure from an Island, in Latitude 56 deg. 25 min. North, and sails N.N.E. for several Days, and then finds herself by Observation to be in Latitude 68d. 30m. North; I demand the Distance sailed, with her Departure and Difference of Longitude.

See the same Question in *Mercator's* Sailing, Case the Second. The Difference of Latitude is 12d. 5m. or 725 Min. or Miles.

Then for the Distance.

	d.	m.		
As Sine Comp. of Course ——	22	30	——	9.96561
To Difference of Latitude ——		725	——	2.86033
So is Radius —— ——	90	00	——	10.00000
To the Distance— — ——		785	——	2.89472

Then for the Departure.

	d.	m.		*Co. Ar.*
As Sine Comp. of Course —	22	30	——	0.03439
To Difference of Latitude ——		725	——	2.86033
So Sine of the Course, Sine —	22	30	——	9.58284
To Departure —— ——		300	——	2.47756

The two Latitudes {	56d.	25m.
	68	30
Sum —— ——	124	55
Half Sum ——	62	28 the Middle Latitude req.

	d.	m.		
As Sine Comp. of Mid. Lat. —	62	28	—	9.66489
To Radius — — — —	90	00	—	10.00000
So Departure — — —		300	—	2.47712
To Difference of Longitude —		649	—	2.81223

CASE III. *Both Latitudes and Diſtance given, to find the Courſe, Departure and Difference of Longitude.*

A Ship in Latitude of 55d. 00d. North, ſails between the North and the Eaſt 86 Miles, and is then come into Latitude 56d. 10m. North; her Courſe, Departure, and Difference of Longitude is required.

See the ſame Queſtion, (only inverted, what is required there being given here) in *Mercator's Sailing, Caſe* the fifth.

For the Courſe.

As Diſtance — — —		86	—	1.93449
To Radius — — —	90d.	00m.	—	10.00000
So Difference of Latitude —		70	—	2.84509
To Sine Comp. of Courſe —	35	31	—	9.91060

For the Departure.

	d.	m.		
As Radius — — —	90	00	—	10.00000
To the Diſtance — — —		86	—	1.93449
So Sine of the Courſe —	35	31	—	9.76413
To Departure — — —		50	—	1.69862

For the Difference of Longitude.

	d.	m.		*Co. Ar.*
As Sine Comp. of Mid. Lat. —	55	35	—	0.24779
To Tang. of the Courſe —	35	31	—	9.85086
So Difference of Latitude —		70	—	1.84509
To Diff. of Longitude —		88	—	1.94374

Or,

	d.	m.	
As Sine Comp. of Mid, Lat. —	55	35	— 9.75220
To Radius —	90d.	oom.	— 10.00000
So Departure —		50	— 1.69897
To Difference of Longitude —		88	— 1.94677

CASE IV. *Both Latitude and Departure given, to find Course, Distance, and Difference of Longitude.*

A Ship in Latitude 55d. oom. North, sails between the North and East into Latitude 56d. 10m. North, her Departure 50 Minutes; the Course, Distance and Difference of Longitude is required.

See the same Question in *Mercator's Sailing*, Case the fifth.

For the Course by Case the Sixth of Plane Sailing.

As Difference of Latitude —		70	— 1.84509
To Radius —	90d.	oom.	— 10.00000
So Departure —		50	1.69897
To Tangent of the Course —	35	32	9.85388

For the Distance.

	d.	m.	
As Sine of the Course —	35	32	9.76430
To Departure —		50	— 1.69897
So Radius —	90	00	10.00000
To the Distance —		86	— 1.93467

For the Difference of Longitude.

	d.	m.	
As Sine Comp. of Mid. Lat. —	55	35	— 9.75220
To Radius —	90	00	— 10.00000
So Departure —		50	— 1.69897
To the Difference of Longitude —		88	1.94677

CASE V. *Both Latitudes and Difference of Longitude given, to find Courſe, Diſtance and Departure.*

I demand the Courſe, Diſtance and Meridian Diſtance between two Places, one in Latitude 56d. 15m. North, and the other in Latitude 58d. 35m. North, their Difference of Longitude 2d. 30m.

See *Mercator*, Caſe the Sixth.

For the Courſe.

As Difference of Latitude,		140	*Co. Ar.*	7.85387
To Difference of Longitude		150		2.17609
So Sine Comp. of Mid. Lat.	57d.	25m.		9.73120
To Tangent of the Courſe	29	59		9.76116

For the Diſtance.

	d.	m.		
As Sine Comp. of Courſe	60	01		9.93760
To Difference of Latitude		140		2.14612
So Radius	90	00		10.00000
To the Diſtance		162		2.20852

For the Departure.

	d.	m.		*Co. Ar.*
As Sine Comp. of the Courſe	29	59		0.96239
To Difference of Latitude		140		2.14612
So Sine of the Courſe	29	59		9.69875
To Departure		81		1.90726

Theſe Five are the moſt neceſſary and uſeful Caſes in *Middle Latitude*, and indeed all that are of Uſe in keeping a Reckoning; yet there are ſeveral other Caſes, which I ſhall inſert for Variety; but becauſe they are not ſo neceſſary in Practice, I ſhall only ſet down the *Date* and *Quæſita*, with the Canons or Proportions for finding what is required, and ſhall leave the Operations for the Reader's Practice.

CASE

CASE VI. *One Latitude, Course and Departure given, to find the other Latitude, Distance and Difference of Longitude.*

A Ship in Latitude 55d. oom. North, sails North 35d. 32m. Easterly, till her Departure be 50; I demand as above.

For the Difference of Latitude.

As Sine Course to Departure, so Sine Comp. of Course to Diff. of Latitude.

The Difference of Latitude thus found, the Latitude come to is easily found, as in *Mercator*, Case the first; and both Latitudes being found, the Middle Latitude is found, as in *Middle Latitude Sailing*, Case the first. Then,

For the Distance.

As Sine of the Course to Departure, so Radius to the Distance.

For the Difference of Longitude.

As Sine Comp. of Mid. Lat. to Radius, so Departure to Diff. of Longitude.

CASE VII. *One Latitude, Distance and Departure given, to find the other Latitude, Course and Difference of Longitude.*

For the Course.

As Distance to Radius, so Departure to Sine of the Course.

For the Difference of Latitude.

As Radius to the Diſtance, ſo Sine Comp. of the Courſe to the Difference of Latitude.

For the Difference of Longitude.

As Sine Comp. of Middle Latitude to Radius, ſo Departure to Difference of Longitude.

CASE VIII. *Courſe, Departure and Difference of Latitude given, to find both Latitudes and Diſtance.*

For the Diſtance.

As Sine of the Courſe to Departure, ſo Radius to the Diſtance.

For the Difference of Latitude.

As Sine of the Courſe to Departure, ſo Sine Comp. of the Courſe to Difference of Latitude.

For the Middle Latitude.

As Difference of Longitude to Departure, ſo Radius to Sine Comp. of Middle Latitude.

The Middle Latitude and Difference of Latitude thus found, both Latitudes are eaſily found; for adding half the Difference of Latitude to the Middle Latitude, the Sum is the greater Latitude, and ſubtracting the ſaid Half from the Middle Latitude, the Remainder is the leſſer Latitude.

CASE

CASE IX. *Middle Latitude, Courſe and Diſtance given, to find both Latitudes, Departure and Difference of Longitude.*

For Difference of Latitude, and conſequently both Latitudes.

As Radius to the Diſtance, ſo Sine Comp. of Courſe to Diff. of Latitude.
Then find both Latitudes, as in Caſe the Eighth.

Then for Departure by Caſe the firſt of Plane Sailing.

As Radius to the Diſtance, ſo Sine of the Courſe to Departure.

For the Difference of Longitude.

As Sine Comp. of Middle Latitude to the Sine of the Courſe, ſo is the Diſtance to the Difference of Longitude.

CASE X. *Courſe, Diſtance, and Difference of Longitude given, to find both Latitudes and Departure.*

For the Middle Latitude.

As Difference of Longitude to the Diſtance, ſo is Sine of the Courſe to Sine Comp. of Middle Latitude.

For the Difference of Latitude.

As Radius to the Diſtance, ſo Sine Comp. of Courſe to Difference of Latitude.
Then find both Latitudes as in Caſe the Eighth.

For the Departure.

As Radius to the Diſtance, ſo Sine of the Courſe to Departure.

CASE

CASE XI. *Courſe, Difference of Latitude, and Difference of Longitude given, to find both Latitudes, Diſtance and Departure.*

For the Middle Latitude.

As Difference of Longitude to Difference of Latitude, ſo is Tangent of the Courſe to Sine Comp. of Middle Latitude.

By Difference of Latitude and Middle Latitude find both Latitudes, as in Caſe the Eighth.

For the Diſtance.

As Sine Comp. of the Courſe to the Difference of Latitude, ſo is Radius to the Diſtance.

For the Departure.

As Sine Comp. of the Courſe to the Difference of Latitude, ſo Sine of the Courſe to the Departure.

CASE XII. *Middle Latitude, Courſe and Difference of Longitude given, to find both Latitudes, Diſtance and Departure.*

As Tangent of the Courſe, to Sine Comp. of Middle Latitude, ſo Difference of Longitude to Difference of Latitude.

Then find Diſtance and Departuae, as in Caſe the Eleventh.

CASE XIII. *On Latitude, Departure, and Difference of Longitude given, to find the other Latitude, Courſe and Diſtance.*

As Difference of Longitude to Departure, ſo Radius to Sine Comp. of Middle Latitude.

Subtract

Subtract the given Latitude and Middle Latitude the leſs from the greater, the Remainder doubled is the Difference of Latitude.

Then for the Courſe.

As Difference of Latitude to Radius, ſo Departure to Tangent of the Courſe.

Then for the Diſtance.

As Sine of the Courſe to Departure, ſo Radius to the Diſtance.

CHAP. III.

Navigation by Inſpection.

SECT. I.

How to work all the Caſes in Plane Sailing, and to work a Traverſe; and alſo to keep a Reckoning both in Longitude and Latitude, only by Inſpection in the Table of Difference of Latitude and Departure.

IN all Caſes of Plane Sailing, there are always four Terms, *viz.* Courſe, Diſtance, Difference of Latitude and Departure, two of which are always given, to find the other two; and in the Traverſe Table, the Courſe is to be found in the Degrees, Points, or Quarter Points,

At

at the Top or Bottom of each Leaf. The Diſtance is found in the firſt and laſt Column of each Page, and the Difference of Latitude and Departue are found in the reſt of the Columns in the Body of each Leaf Side; and which two of the Terms ſoever you have given, they being found in their proper Places, the two required Terms may alſo be found in the correſponding Columns: I ſhall inſtance in Example of all the ſix Caſes of Plane Sailing.

CASE I. *Courſe and Diſtance given, to find Difference of Latitude and Departure.*

A Ship ſails S. 25 Deg. E. 96 Miles; I demand her Difference of Latitude and Departure.

In this Table, the Left-hand Page in the Columns of Diſtance proceeds from 1 to 50, and the Right-hand Page from 50 to 100, and the given Diſtance here being above 50, *viz.* 96, look along the Top of the Right-hand Pages till you find 25 deg. and right under it, and againſt 96, the Diſtance you find 87d. om. for the Difference of Latitude, and 40d. 6m. for the Departure, as the Title at the Top directs.

But ſuppoſe your Courſe hath been South 65 Degrees Eaſt, you find 65 Degrees at the Bottom of the ſame Column where you find 25 at the Top, and againſt 96, the Diſtance, you find Difference of Latitude, and Departure the ſame, *viz.* 87 : 0, and 40 : 6, only with this Alteration, that now 87 : 0, is the Departure, and 40 : 6 is the Difference of Latitude; whereas before it was contrary: But to avoid Miſtakes herein, obſerve where you find the Degree of the Courſe whether at the Top or Bottom of the Table, there find alſo the Title of the Columns of Difference of Latitude and Departure: Thus, in the firſt Example of 25 Degrees, you find the Degree at the Top, and therefore the Title alſo at the Top, ſhews that the firſt of the two Columns is Difference of Latitude, and the ſecond the Departure; but in the ſecond Example of 65 Degrees, you find the Degree at the Bottom, and therefore the Title being alſo found at the Bottom, ſhews the firſt Column is the Depar-

Departure, and the ſecond the Difference of Longitude, *&c.*

But ſuppoſe my Diſtance be above 100 Miles, as in the firſt Example of *Plane Sailing* in the Book, which is, a Ship ſails N.W. by N. 123 Miles; I demand her Difference of Latitude and Departure.

Here, becauſe the Table reaches but to 100, you muſt take it out at twice; thus the Courſe being N.W. by N. 3 Points, I look for 3 Points, which I find at the Top of the Leaf, and under it againſt 100, I find,

	Diff. Lat.	*Dep.*
	83 : 1	55 : 6
Then againſt 23 I find under 3 Points	19 : 1	12 : 8
	102 : 2	68 : 4

Theſe Sums added ſeverally, give 102 : 2 for the Difference of Latitude and 68 : 4 for the Departure.

But ſuppoſe your Diſtance were ſo great a Number, that it would require to be taken out at a great many Times, is in the Queſtion in Caſe I. of *Mercator's Sailing Trigonometrical*, A Ship ſails 987 Miles N.W. by N. *&c.* you may alſo take this out at twice; for having found 3 Points, you may take out firſt for 980, and then for 7 thus; look under three Points, till you come down againſt the Diſtance 98, and againſt it you have 81 : 5, for Difference of Latitude, and 54 : 4 for the Departure; but becauſe the 98 is advanced a Figure or Place towards the Left-hand, and called 980, and therefore advance the other alſo a Place to the Left-hand, then will the Diff. of Latitude, 81 : 5, become 815, and the Departure 54 : 4, will be 544: then finding alſo for the 7, becauſe the whole Diſtance is 987, the Work will ſtand as in the Margin, and the Difference of Latitude is 820 : 8, and Departure, 547 : 9.

Diff. Lat.	*Dep.*
815	544
5 : 8	3 : 9
820 : 8	547 : 9

Another

Another Method very proper when your given Diſtance exceeds what is found in the Table, is to take $\frac{1}{2}$, $\frac{1}{3}$, or $\frac{1}{4}$, *&c.* of your given Diſtance, and find the Diff. of Lat. and Departure belonging to that, which being doubled, if you took half, or tripled, if you took One-third, or multiplied by 4, if you took One-fourth, *&c.* of the given Diſtance; the Numbers ſo found ſhall be the Difference of Latitude and Departure requried

Example.

A Ship ſails S.S.W. 120; I demand Diff. Latitude and Departure.

Here, becauſe the Table goes not ſo far as 120, I take the Half of it, *viz.* 60, and againſt it under two Points (becauſe S.S.W. is two Points from the Meridian) I find 55 : 4, for Difference of Latitude, and 23 : 0, for the Departure; which two Numbers being doubled, (becauſe I took but half the Diſtance) gives 110 : 8, for the Difference of Latitude, and 46 : 0, for the Departure, *&c.*

CASE II. *Courſe and Difference of Latitude given, to find Diſtance and Departure.*

A Ship ſails North 28 Deg. Weſterly, till her Difference of Latitude be 120 Miles; I demand her Diſtance and Departure.

Becauſe 120 is not to be found in the Table, I take half of it, *viz.* 60, and finding 38 Deg. at the Top, I look under it till I find 60 under [Lat.] for Difference of Latitude, and right againſt it, in the Column of Diſtance, I find 76, which doubled is 152, the Diſtance required, and againſt it under [Dep.] I find 46 : 8, which doubled is 93 : 6, the Departure required.

CASE III. *Courſe and Departure given, to find the Diſtance and Difference of Latitude.*

A Ship ſails S.W. by S. till her Departure be 40 Miles; I demand Diſtance and Difference of Latitude.

Find the Points at the Top, and under it, in the Column of Departure, find 40; againſt which you find 72 for the Diſtance, and 59 : 8; for the Departure.

CASE IV. *Diſtance and Difference of Latitude given, to find Courſe and Departure.*

A Ship ſails 71 Miles in the S.W. Quarter, her Difference of Latitude 59 Miles; I demand Courſe and Departure.

Look for 71 in the Column of Diſtance, and run over the ſeveral Columns of your Table, till you find 59 in one of the other Columns againſt it, which being found, obſerve where you find the Title [Lat.] whether at the Top or Bottom of the Table; for there you find alſo the Courſe, as in this Example. I run over the Table, till againſt 71, I find 59 : 0; and the Title [Lat.] being at the Top, I find alſo the Courſe at the Top, *viz.* 3 Points, or S.W. by S. and Departure 39 : 4.

CASE V. *Diſtance and Departure given, to find Courſe, and Difference of Latitude.*

A Ship ſails between the South and Eaſt 100 Miles, her Departure 53 Miles; I demand the Courſe and Difference of Latitude.

Look for 100 in the Column of Diſtance, and againſt it run over your Table till you find 53 for the Departure, and over it you find 32 Degrees for the Courſe, and 84 : 8, for the Difference of Latitude required.

CASE VI. *Difference of Latitude and Departure given, to find the Courſe and Diſtance.*

A Ship ſails between the North and Eaſt, till her Difference of Latitude be 56 : 0, and her Departure 35 : 0; I demand the Courſe and Diſtance.

Look through the Columns of Diff. of Lat. and Departure, till you find 56 : 0, againſt 35 : 0, and over that you find 32 Degrees for the Courſe, and 66 Miles for the Diſtance, *&c.*

Note, You cannot always find exactly the Numbers given, but find the neareſt you can, which will generally be of ſufficient Exactneſs for common Uſe.

SECT. II.

How to work a Traverſe by the Tables of Difference of Latitude and Departure.

THIS is the principal Thing for which theſe Tables are of Uſe, and this Way of working a Traverſe is equal to the beſt for Exactneſs, and much more expeditious; and therefore I have on Purpoſe omitted Traverſe Sailing in the Geometrical Part hereof, as being too tedious for Practice at Sea.

I ſhall inſtance in Queſtion the firſt of *Traverſe Sailing Geometrical*, and ſhall ſolve the ſame here by the Table.

A Ship S.S.E. 30 Miles, then N.E. by N. 40 Miles, then E. by N. 25 Miles, then N.N.E. 44; I demand the Courſe, Diſtance, Difference of Latitude and Departure, from the Place ſailed from.

Firſt, Make a little Table with ſix Columns, as you ſee in the following Page.

The

The firſt is the Courſe.
The ſecond the Diſtance.
The third the Northing.
The fourth the Southing.
The fifth the Eaſting.
The ſixth the Weſting.

Courſe.	*Diſt.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
S. S. E.	30		27 : 7	11 : 5	
NE. by N.	40	33 : 3		22 : 2	
E. by N.	25	4 : 9		24 : 5	
N. N. E.	44	40 : 6		16 : 8	
		78 : 8	27 : 7	75 : 0	
		27 : 7			
		51 : 1			

Then by *Caſe* I. find the Difference of Latitude and Departure to every Courſe, and ſet them in their proper Columns; as where the Courſe is Northerly, ſet the Difference of Latitude under Northing, or in the North Column; and where the Courſe is Southerly, ſet the Difference of Latitude in the South Column.

Again, when the Courſe is Eaſterly, ſet the Departure in the Eaſt Column, and when the Courſe is Weſterly, ſet the Departure in the Weſt Column; then adding up each Column by itſelf ſubtract the North and South Columns, the leſſer from the greater, the Remainder is the Northing or Southing made good. Alſo ſubtract the Eaſt and Weſt Columns, the leſſer from the bigger, the Remainder is the Eaſting or Weſting made good; then have you Difference of Latitude and Departure given, to find the Courſe and Diſtance, by *Caſe* VI.

In this Example, the firſt Courſe is E.S.E. 30 Miles; or two Points 30 Miles; for which, by *Caſe* I. I find the Difference of Latitude 27 : 7. Now the Courſe being between South and Eaſt, I place my Difference of Latitude in the South Column, and my Departure 11 : 5, in the Eaſt Column, leaving the North and Weſt Columns blank.

Then for the ſecond Courſe, N.E. by N. or 3 Points, 40 Miles, here my Difference of Latitude 33 : 3, is to be placed in the North Column, and the Departure 22 : 2, in the Eaſt Column, becauſe the Courſe is between the North and Eaſt.

Then the third Courſe being E. by N. or 7 Points, 25 Miles, I place my Difference of Latitude, 4 : 9, in the North Column, and Departure, 24 : 5, in the Eaſt Column.

And ſo for the fourth Courſe, N.N.E. or two Points, 44 Miles, I place my Difference of Latitude, 40 : 6, in the North Column, and my Departure, 16 : 8, in the Eaſt Column, and then adding up each Column, the Sum of the Northing Column is 78 : 8, and the Sum of the Southing Column is 27 : 7, which ſubtracted from the Northing 78 : 8, the Remainder 51 : 1, is the Difference of Latitude made good, which is Northing, becauſe the Northing was the greater Number.

Again, the Sum of the Eaſting Column is 75 : 0, which (becauſe there is no Weſting to ſubtract from it) is the Eaſting made good. Thus you have the Northing, 51 : 1, and the Eaſting, 75 : 0, given, to find Courſe and Diſtance, by *Caſe* VI. and although you cannot find in the Table the exact Numbers of 51 : 1, and 75 : 0, together, yet find the neareſt you can, which is 75 : 4, and 50 : 9, over which at the Top, you find 34 Degrees for the Courſe, which is N.E. by N. od. 15m. Eaſterly, and the Diſtance 91 Miles.

But if you have a Place propoſed that you are bound for, whoſe Courſe and Diſtance from the Place ſailed from is given, find thereby the Difference of Latitude and Departure to the Place bound for, from which ſubtract the Difference of Latitude and Departure, made good, (if it be the leſſer Number, or the other from it, if

if one of them be the greater Number) the Remainder is the Difference of Latitude and Departure from the Ship to the Place bound for, by which you may find the Courſe and Diſtance by *Caſe* VI.

Example. In the firſt Queſtion in *Traverſe Sailing Geometrical*, there is a Place propoſed to be ſail'd to, diſtant 129 Miles N.E. half E. the Difference of Latitude for that Courſe and Diſtance is found by *Caſe* I. to be 76 : 2, and the Departure, 92 : 8. Now the Difference of Latitude made good by the Ship being but 51 : 1, if ſubtracted from the whole Difference of Latitude to the Place bound for, 76 : 2, it is evident that the Remainder, 25 : 1, muſt be the Difference of Latitude from the Ship to the Place bound for. Alſo the Departure made good by the Ship, 75 : 0, ſubtracted from the whole Departure, 92 : 8, the Remainder, 17 : 8, is the Departure from the Ship to the Port bound for. And thus you have the Difference of Latitude, 25 : 1, and the Departure, 17 : 8, to find the Courſe and Diſtance by *Caſe* VI. and the neareſt to theſe two Numbers that can be found is 25 : 4, and 17 : 8, over which you have 35 Deg. for the Courſe, and againſt it 31 Miles for the Diſtance, *viz.* N.E. by N. 1d. 15m. Eaſterly, 31 Miles is the Courſe and Diſtance to the Place bound for, *&c.*

But ſuppoſe the Difference of Latitude made good by the Ship were more than the Difference of Latitude to the Port bound for, you muſt ſubtract the leſſer from the greater, and the Remainder is the Difference of Latitude from the Ship to the Port, but of a contrary Denomination, which ſeems to be ſo plain, that it needs no Example; for if a Man intends to travel to a Place that bears due North from him 12 Miles; if a Man travels 15 Miles due North, his Courſe from thence to the Place bound for is South 3 Miles; even ſo if a Ship intending for the Port aforeſaid, whoſe Difference of Latitude is 76 : 2 North, and Departure 92 : 8 Eaſt, ſhould ſail between the North and Eaſt, till her Difference of Latitude be 100 North, and Departure 75 : 0 Eaſt, tis plain ſhe is to the Northward of her Port; becauſe ſhe has got more Difference of Latitude Northerly; and ſhe

is alſo to the Weſtward of her Port, becauſe ſhe hath not got ſo much Departure Eaſterly; and therefore ſubtracting the leſſer Difference of Latitude from the greater, the Remainder, 23 : 8, is the Difference of Latitude Southerly from the Ship to the Port bound for; and the Departure 57 : 0, ſubtracted from the whole Departure, 92 : 8, the Remainder, 17 : 8, is the Departure Eaſterly from the Ship to the Port bound for; and in this Caſe the Courſe and Diſtance would be found by *Caſe* VI. to be S.E. by S. ¼ S. 29 : 05 Miles.

SECT. III.

How to find the Difference of Longitude by the Table of Difference of Latitude and Departure.

HAVING one Latitude, Courſe and Diſtance given, or both Latitudes and Courſe, *&c.* you may find the reſt according to *Plane Sailing*, by the foregoing Rules, which being done, find the Middle Latitude, (always obſerving that Caution, to take a Latitude rather too big than too little, where the Middle Latitude cannot exactly be had without a Fraction, then the Rule is:

Find the Complement of Middle Latitude amongſt the Degrees at the Top or Bottom of the Table, and under it, (if you find it at the Top, or above it, if you find it at the Bottom) in the Column of Departure, find your Departure, and right againſt it, in the Column of Diſtance, is the Difference of Longitude.

And although this Method is not ſo practicable in great Numbers, yet it is very uſeful at Sea, for working a Day's Run, or the like, which ſeldom exceeds 50 or 60 Leagues; and therefore I ſhall recommend it to the Learner, as the moſt expeditious Method, and of ſufficient exactneſs for ſhort Diſtances; here being Methods ſufficient laid down in this Treatiſe for more exactly correcting the Reckoning once or

or twice in a Week, of which more when we come to that Part.

Note, If you think it too much Trouble to ſubtract the Middle Latitude from 90, to find its Complement; you may find the Middle Latitude amongſt the Degrees, as before; and find the Departure in the Column of Difference of Latitude, and againſt it, in the Column of Diſtance, you have the Difference of Longitude as before.

I ſhall give an Example or two, and refer the Reader for further Practice of this Method to the Examples laid down for keeping a Reckoning in the latter Part of this Book, where I ſhall illuſtrate this Method by Example, and ſhew its general Agreement with the Longitude, as found by *Mercator's Sailing*.

Example 1. A Ship in Latitude 55 : 0 North, ſails in the North Eaſt Quarter, into Latitude 56 : 10, her Departure 50; I demand Courſe, Diſtance, and Difference of Longitude.

See the Queſtion in *Caſe* IV. of Middle Latitude ſailing Trigonometrical.

Difference of Latitude 70, Departure 50, the Courſe will be found by *Caſe* VI. hereof to be 36 Degrees neareſt; omitting the Minutes, and the Diſtance 86.

The Middle Latitude is 55 : 35, but becauſe we have only whole Degrees, we muſt uſe either 55 Degrees, or 56; and becauſe, as I ſaid before, it is beſt to take a Degree too great rather than too little, we ſhall call it 56, whoſe Complement 34 found in the Degrees, look under it for the Departure 50, the neareſt Number to which is 49 : 8, againſt which in the Column of Diſtance, I find 89 for the Difference of Longitude required.

Example 2. In *Caſe* V. of Middle Latitude Sailing Trigonometrical.

I demand the Courſe, Diſtance and Difference of Longitude between two Places, one in Latitude 56 : 15 North, the other in Latitude 58 : 35 North, their Meridian Diſtance 81.

Difference of Latitude 140, Departure 81, the Courſe is found by *Caſe* VI. to be an Angle of 30 Degrees from the Meridian, and the Diſtance 162, as you may ſee by the Traverſe Table.

Then for Difference of Longitude, the Middle Latitude is 57 : 25, but we muſt call it in this Caſe 58, which found in the Degrees, there is not ſuch a Number as 81 in the Column of Latitude; therefore find its half 40 : 5, or the neareſt to it, which is 40 : 3, and againſt it, in the Column of Diſtance, you find 76, which doubled is 152, the Difference of Longitude required.

Note, Although in particular Queſtions the Longitude found this Way differs ſometimes a Minute or two from that found by Calculation: becauſe we are obliged to uſe whole Degrees in the Table for Middle Latitude; yet the Error being ſometimes a Minute or two too much, and ſometimes as much too little, the Difference is not diſcernable in a long Reckoning.

CHAP.

CHAP. IV.

Arithmetical Navigation.

SECT. I.

Plane Sailing Arithmetical.

HAVING thus finiſhed all the Kinds and Caſes of Navigation in the foregoing Book, according to the Method commonly taught, and practiſed both at Sea and a-ſhore, *viz.* by a Canon of Logarithmical Sines, Tangents and Secants, (together with the Help of the Logarithms and Natural Numbers) my next Work is (according to my Promiſe) to ſhew, how all the aforeſaid Kinds of Navigation may be compleatly performed without any Canon, only by the Help of ſome given Numbers, which ſhall be inſerted in their proper Places, which are of Uſe where the Courſe is either given or required: And firſt in Order, I ſhall begin with *Plane Sailing*, in which the three firſt Caſes are wrought only by the Table of given Numbers, as alſo are thoſe Queſtions in the three laſt Caſes where the Courſe is required: But the Solution of all Queſtions in *Plane Sailing*, when two Sides are given to find a third (as Diſtance and Difference of Latitude given to find Departure, *&c.*) are grounded upon that known Propoſition in *Euclid*, *Lib.* 1. *Prob.* 47. *viz.* That the Square of the Hypotenuſe (called there the Baſe, becauſe it is the longeſt Side) of a right-angled Triangle, is equal to the Squares of both Legs added together. Hence then (the Hypotenuſe repreſenting the Diſtance, and the two Legs the Difference of Latitude

and

and Departure (if you ſquare each Leg, that is, multiply each Leg by itſelf) theſe two Sums added together ſhall be equal to the Square of the Hypotenuſe; and conſequently, if from the Square of the Hypotenuſe you ſubtract the Square of one Leg, the Remainder is the Square of the other Leg, as may be proved by thoſe three known Numbers, 3, 4, and 5, which three Numbers make a Right-angled Triangle; the two Legs being 3 and 4, and the Hypotenuſe 5: Now if you ſquare the two Legs, 3 times 3 is 9, and 4 times 4 is 16, which two Squares of 16 and 9 added together, the Sum is 25, the Square of 5, the Hypotenuſe. Again, if from 25, the Square of the Hypotenuſe, you ſubtract 16, the Square of one Leg, there remains 9, the Square of the other Leg, *&c.* And when the Square of any Side is thus found, the Square Root thereof (found as is ſhewn in the firſt Part hereof) is the Side required.

Alſo with reſpect to the given Numbers, if Courſe and Diſtance be given, multiply the Diſtance by the given Numbers, as the Title of the Table directs for Latitude and Departure, (whoſe Uſe follows in ſeveral Examples) the Sum, abating as many Figures to the Right-hand as you multiply by, is the Difference of Latitude or Departure required: Now if the Hypotenuſe multiplied by the given Number produce a Leg, only two Figures to be cut off, the ſaid Leg being given, and two Figures (or Cyphers) added to it, and divided by the ſaid given Number, the Quotient muſt needs be the Hypotenuſe; and if ſo, then if the ſaid Leg, with two or more Figures (or Cyphers) added to it, be divided by the Hypotenuſe, the Quotient muſt needs be the given Number, as is apparently evident to almoſt every Body that have but learned the firſt Rudiments of Arithmetick, and underſtand (what every School-Boy is taught) how Multiplication and Diviſion will undo and prove each other; and hence any two Parts of a Queſtion of *Plane Sailing* being given, the reſt may be found by the Square Root, and one Table of given Numbers, all the Caſes except the ſixth, being wrought immediately by the given Numbers; and even in the ſixth Caſe, where the two Legs are given, the Hypotenuſe or Diſtance may be found by the Square

Square Root, and then the Courſe as in the other Caſes; as I ſhall explain by the following Example.

A *TABLE of* Given Numbers.

Points	*Latitude*	*Depart.*	*Points*
0 ¼	99 : 88	04 : 88	7 ¼
0 ½	99 : 52	09 : 76	7 ½
0 ¾	98 : 92	14 : 66	7 ¾
1	98 : 08	19 : 51	7
1 ¼	97 : 01	24 : 27	6 ¼
1 ½	95 : 71	28 : 99	6 ½
1 ¾	94 : 15	33 : 71	6 ¾
2	92 : 39	38 : 27	6
2 ¼	90 : 40	42 : 77	5 ¼
2 ½	88 : 20	47 : 13	5 ½
2 ¾	85 : 79	51 : 38	5 ¾
3	83 : 15	55 : 56	5
3 ¼	80 : 33	59 : 55	4 ¼
3 ½	77 : 29	63 : 45	4 ½
3 ¾	74 : 10	67 : 15	4 ¾
4	70 : 71	70 : 71	4
Points	*Depart.*	*Latitude*	*Points*

The Uſe of this Table is for working the ſix Caſes of *Plane Sailing*, in which obſerve, that in the firſt and laſt Columns you have the Rumbs or Points of the Compaſs, with the half Points, and quarter Points, numbered from the Meridian, or North and South Line, either Eaſt or Weſt, according as they ſtand in Order; thus S. S. W. is two Points, becauſe South is upon the Meridian, then S. by W. is one Point, and S.S. W. two Points, *&c.* So likewiſe N. N. E. and N. N. W. is two Points from the North. Again, ſuppoſe a Ship ſails S. W. ½ S. that is, three Points and an half, and N. N. E. ¼ E. is two Points and a Quarter; which being a Thing ſo commonly known, I ſhall not need to add any more Examples.

The Number of Points thus found, obſerve on which Side of the Table it is found, for if you find the Courſe at the Left-hand, then find the Denomination of Latitude and Departure at the Top: But if the Courſe be on

on the Right-hand find the Denomination of Latitude and Departure at the Bottom; for the Left-hand Column contains all the Points under four Points, and the Right-hand Columns contains all the reſt of the Points to eight. Now if the Courſe be found in the firſt Columns, (*viz.* leſs than four Points) then the ſecond Column is the given Number for Difference of Latitude, and the third Column is the given Numbers to find Departure: But if the Courſe be in the laſt Column, (*viz.* about four Points) then the third Column is the given Numbers to find Difference of Latitude, and the ſecond is for the Departure, *&c.* And the Uſe of the Table being thus known for the firſt Caſe, the reſt is eaſily found by Conſequence, as we have hinted before, and ſhall make it evident and intelligible to the meaneſt Capacity, by the following Examples.

Note; If you have a given Number, with a Cypher on the Left-hand, (as in 7 $\frac{1}{2}$ and 7 $\frac{1}{4}$ Points) although a Cypher adds nothing to the Product (being on the Left-hand) yet it cauſeth a Figure more to be cut off from the Decimal Fraction; and having cut off as many Figures towards the Right-hand as you multiply by, the reſt is the Latitude or Departure ſought, and thoſe cut off are a Numerator of a Decimal Fraction to a Denominator, conſiſting of as many Cyphers as you cut off Figures, with a 1 at the Left-hand; ſo if you cut off 97, it is $\frac{97}{100}$, or if you cut off 342, it is $\frac{342}{1000}$, and ſo of the reſt.

Note; When you have found the given Number in the Table, you need not always uſe all the four Figures, eſpecially, if the third or fourth be a ſmall Digit, as 1 or 2, as ſuppoſe your given Number be 8315, here the third Figure being a 1, you may cut off the two laſt Figures, and uſe only 83 to work with. Again, if the third Figure be one of the higheſt Digits, as 8 or 9, you may cut off the two laſt only add one to the ſecond Figure, and ſo work as before; as ſuppoſe your Number be 2899, you may add 1 to the ſecond Figure, *viz.* 8, and then cut off the two laſt, and then your Number to work with will be 29; the Reaſon of all which is very evident to any that underſtand the Nature of Decimals, and

and will by a little Practice become eaſy to the meaneſt Capacity.

Plane Sailing.

CASE I. *Courſe and Diſtance given, to find the Difference of Latitude and Departure.*

The RULE.

Multiply the Diſtance by the given Numbers for the Courſe, and from the Product cut off as many Figures as you multiply by, and the reſt is Difference of Latitude and Departure required.

Queſtion. A Ship ſails N.W. by N. 123 Miles; I demand her Difference of Latitude and Departure?

The given Number for Difference of Latitude being 8315, we ſhall only uſe 83, and cut off the other two Figures (towards the Right-hand) and multiplying the Diſtance 123, by the given Number 83, and from the Product cut off two Figures, (becauſe you multiply by two Figures) you have Difference of Latitude; but for Departure the given Number is 5556, the third Figure being a 5, we ſhall for more Exactneſs uſe three Figures, *viz.* 555, and work as before: The Operation for Difference of Latitude and Departure will ſtand thus:

For the Diff. of Latitude.	*For Departure.*
123	123
83	555
369	615
984	615
	615
102|09	68|265

The

The Difference of Latitude is 102 $\frac{90}{100}$, the Departure is 68 $\frac{165}{100}$; but you need not regard the Fractions, only if a Fraction be conſiderable above half of one Mile, or Minute, you may add 1 to the whole Number; as ſuppoſe your Fraction be 78, *viz.* $\frac{78}{100}$, you may add 1 to the whole Number, and reject the Fraction, *&c.*

Another Example in Caſe I.

A Ship ſails N.N.W. $\frac{1}{2}$ W. 165 Miles; I demand the Difference of Latitude and Departure.

N.N.W. $\frac{1}{2}$ W. is 2 $\frac{1}{2}$ Points.

For Diff. of Lat.		*For Depart.*
165		165
88		47
1320		1155
1320		660
145|20	Diff. Lat. 145.	77|55

Dep. 77, or rather 78, becauſe the Fraction is $\frac{55}{100}$.

CASE II. *Courſe and Difference of Latitude given, to find Diſtance and Departure.*

The RULE.

For the Diſtance, add as many Cyphers to the Difference of Latitude as the Number of Figures you think to make uſe of in the given Number, and then divide it by the given Number, and the Quotient is the Diſtance, which being found, find the Departure as in *Caſe* I.

Queſtion. A Ship ſails S.W. by S. till her Difference of Latitude be 174; I demand the Diſtance and Departure.

Then

The Courſe is 3 Points, the given Number 8315 and 5556.

For the Diſtance.	*For Departure.*
83)17400(209 *Diſt.*	209
800	555
53	1045
	1045
	1045
	115|995

The Diſtance 209, and Departure 115, or rather 116, becauſe the Fraction is ſo great, *viz.* above $\frac{995}{1000}$.

CASE III. *Courſe and Departure given, to find Diſtance, and Difference of Latitude.*

The RULE.

Add ſo many Cyphers to the Departure as you think to uſe Figures in the given Number; and then divide by the given Number anſwering to Departure, and the Quotient is the Diſtance, which being found, find the Difference of Latitude, as in *Caſe* I.

Queſtion. A Ship ſails N. by E. ½ E. till her Departure be 72; her Diſtance and Difference of Latitude is required.

See Example the ſecond, in *Caſe* III. of *Plane Sailing.*

For

For the Diſtance	*For Diff. Lat.*
337)72000(213	214
.460	94
1230	856
219	1626
	201|16

The Diſtance is 214, (being ſo large a Fraction) and the Difference of Latitude is 201.

CASE IV. *Diſtance and Difference of Latitude given, to find the Courſe and Departure.*

The RULE.

Square the Diſtance (that is, multiply it by itſelf) and likewiſe the Difference of Latitude, and ſubtract the leſſer Number from the greater, the Square Root of the Remainder is the Departure required; and then for the Courſe, add two or three Cyphers to the Difference of Latitude, and divide that Sum by the Diſtance, the Quotient is the given Number for the Courſe, which being found in the Table, you have againſt it the Courſe required.

Note; If you cannot find exactly the ſame Numbers (which ſeldom happens) find the neareſt to it, which is ſufficient, and find the Courſe to the neareſt Quarter Point.

Queſtion. A Ship ſails between the North and Eaſt 100 Miles; and then finds by Obſervation, that ſhe hath raiſed the Pole 1 Degree, or 60 Min. or Miles; I demand the Courſe and Departure.

For

For the Courſe.

110)60000(545
50
600
1100
50
110
12100

For the Departure.

60 60 3600

Sq. of Diſt. 12100
Sq. Diff. Lat. 3600
Diff. of Sq. 8500

8500(92
81
182)400
364
36

The Quotient 545 ſought in the Table, the neareſt given Number is 555, and againſt that, for the Courſe, you have 5 Points, which is N.E. by E. becauſe the Courſe is between North and Eaſt, and the Departure is 92, for you need not regard the Fraction in the Square Root, it being but a ſmall Part of a Mile or Minute in the Departure.

CASE V. *Diſtance and Departure given, to find Courſe and Difference of Latitude.*

The RULE.

Subtract the Square of the Departure from the Square of the Diſtance, the Square Root of the Remainder is the Difference of Latitude; and then find the Courſe as in *Caſe* IV; only mind to find the Quotient in the Departure Column.

Queſtion. A Ship ſails in the S.W. Quarter 124 Miles, her Departure 95; I demand the Courſe and Difference of Latitude.

For the Course.

124)95000(766
·82
·760
16

124
124
496
248
124
15376

For the Diff. of Lat.

95
·95
475
855
9025

Sq. of Dist. — 15376
Sq. of Dist. Lat. 9025
Diff. of Squares 6351

6351(79
49
149)1451
1341
110

The Course is S.W. ¼ W. nearest; for the greatest given Number to the Quotient 766 is 772, which is the Number for four ¼ Points, or S.W. ½ W. and the Difference of Latitude is 79, or rather 80, because the Remainder of the Square Root is so great: And here observe, for a general Rule, that because the last Remainder in the Extraction is a Numerator to twice the Root for a Denominator; therefore if the last Remainder be more than the Root, add one to the Root, and that will be the Root exact enough in this Case; but if the Remainder be less than the Root found, the Root is the nearest whole Number that answers the Question, and you need not regard the Fraction at all: Thus in the Example, *Case* IV. the Root is 92, and the Remainder is but 36, and therefore I keep 92, for the Departure, and reject the Fraction. But in the Example *Case* V. the Root is 79, and the Remainder is more than the Root, *viz.* 110; and therefore I add 1 to 79, and the Sum 80 is the Difference of Latitude required, and so in others.

CASE

CASE VI. *Difference of Latitude and Departure given, to find the Course and Distance.*

The RULE.

Square the Difference of Latitude, and also the Departure, and add the two Squares together; the Square Root of the Sum is the Distance required; and then find the Course, as in *Case* IV, or *Case* V.

Question. A Ship sails in the N.W. Quarter, till her Difference of Latitude be 220, and her Departure 108; I demand the Course and Distance.

For the Distance.

220	108	Square of Diff. Lat.	48400
220	108	Square of Departure	11664
44	864	Sum of the Square	60064
44	1080		
48400	11664	60064(245	
		4	
		44)200	
		176	
		485)2464	
		2425	
		39	

For the Course.

245)220000(897
2400
1950
395

The Course is 2 Points and a Quarter, or N.N.W. ½ W. the Distance 245 Miles.

Although the Operation in this Case seems the most tedious of all the rest, because we have assumed greater Numbers for the *Data* of the Question, yet even in the greatest Number, this Way is much more expeditious

than working by a Canon, as a little Practice will make manifeſt.

SECT. II.

Mercator's Sailing Arithmetical.

WHAT I have wrote of *Plane Sailing* is alſo of Uſe in *Mercator's Sailing*, ſo far as Courſe, Diſtance, Difference of Latitude, and Departure, are Terms either given or required; and the ſame Table of given Numbers is of equal Uſe in both; and as for the Difference of Longitude, it bears the ſame Proportion to the Departure, that the Meridional Difference of Latitude bears to the true Difference of Latitude, by *Euclide*, *Lib.* 6. *Prop.* 4. and indeed by the Help of a Table of Meridional Parts, the whole Practice of *Plane Sailing*, as performed by given Numbers, may be reduced to *Mercator*, by *Euclide*, *Lib.* 6. *Prop.* 4. For being both projected by a Plane Triangle, and the Courſe, whether given or required, being the ſame in both, there muſt needs be the ſame Proportion between the enlarged Diſtance, and the true Diſtance, (being ſuppoſed to be the Hypotenuſes of 2 Equiangular Triangles) or between the Difference of Longitude and Departure, (the Perpendiculars of the ſaid 2 Equiangular Triangles) as there is between the Meridional Difference of Latitude, and the proper Difference of Latitude, (being the Baſes of the ſaid 2 Triangles) and upon theſe Propoſitions the whole Fabrick of *Mercator's Sailing* is grounded; the exact Truth of which is proved not only by the Demonſtration of *Euclide*, in the Propoſition of above-named; but alſo by comparing the Queſtions thereby performed to thoſe in the firſt Part, performed by a Canon, in which I ſhall, for the Reader's Satisfaction, refer to the ſaid Queſtion, as in the following Examples.

CASE

CASE I. *One Latitude, Course and Distance given, to find the other Latitude, Departure and Difference of Longitude.*

The RULE.

Find Difference of Latitude and Departure, as in *Case* I. of *Plane Sailing Arithmetical*; and then for Difference of Longitude, the Proportion is, As proper Difference of Latitude to Meridional Difference of Latitude, so Departure to Difference of Longitude.

Question. A Ship in Lat. 50d. 00m. North, sails N.W. by N. 987 Miles; I demand the Latitude come to, together with her Departure, and Difference of Longitude.

For Difference of Longitude.

987
83

2961
7896

81921

For Departure.

987
555

4935
4935
4935

5477|85

Diff. of Lat. 819 or rather 820, Departure 548, Merid. Diff. of Lat. 1519, then for Diff. Longitude;
As 820 to 1519, so 548 to Diff. of Longitude.

1519
548

12152
6076
7595

832412

820)832412(1015
124
4212
112

CASE II. *Both Latitudes and Courſe given, to find the Diſtance, Departure, and Difference of Longitude.*

The RULE.

Find the Diſtance and Departure, as in Caſe the ſecond of *Plane Sailing Arithmetical*, and then find the Difference of Longitude, as in the firſt Caſe of *Mercator's Sailing.*

Queſtion. A Ship ſails from a Port in Latitude 56d. 25m. North, and ſails away N.N.E. ſeveral Days, and then finds herſelf by Obſervation in Latitude 68d. 30m. North; I demand how far ſhe hath ſailed, and what is his Difference of Longitude?

For the Diſtance.

924)725000)784
·7820
4280
584

For the Departure.

785
383
2355
6280
2355
300|655

As 725 to 1593, ſo 300 to Diff. Longitude.

300
477900

725)477900(659
4290
·6050
125

The Diſtance is 784 $\frac{284}{924}$, or rather 785, the Departure 300, and the Difference of Longitude 659 $\frac{121}{125}$, or 660.

CASE

CASE III. *One Latitude, Course, and Difference of Longitude given, to find the other Latitude, Distance and Departure.*

The RULE.

Add so many Cyphers to the Difference of Longitude as you intend to use Figures in the given Number to divide by, and work as in Case III. of *Plane Sailing Arithmetical*; only observe, that whereas the Quotient there is the true Distance, because you work by Departure, here the Quotient is the enlarged Distance or the whole Hypotenuse, contained between the Angle of the Course, and the Top of the longest Perpendicular representing the Difference of Longitude; and then the enlarged Distance being found, from the Square of the enlarged Distance, subtract the Square of the Difference of Longitude, the Square Root of the Remainder is the Meridional Difference of Latitude, which being found, the one Latitude given, the other Latitude is easily found: Then for Departure, it is only the former Proportion inverted, *viz.* As Meridional Difference of Latitude to proper Difference of Latitude, so Difference of Longitude to Departure.

Question. A Ship in Lat. 55d. 00m. North, sails N.W. half W. till her Difference of Longitude be 1d. or 60m. I demand the Distance, Departure, and Latitude come to.

For the enlarged Distance.

47)6000(127$\frac{11}{47}$
130
360
31

Square of the enlarged Distance — 16285
Square of Diff. of Longitude — 3600
Difference of the Squares — 12685

```
12685(112
1
21)026
21
222)585
444
141
```

Merid. Parts of Lat. fail'd from 54d. 00m. — 3968
Merid. Diff. Lat. add — — — 113

Merid. Parts of Lat. come to — 56 04 — — — 4081

As Merid. Diff. Lat. 113 to proper Diff. Lat. 64, ſo is the enlarged Diſt. 128 to the true Diſt. 73 ½.

```
128
64
512
768
8192
```

```
113)8192(72
·282
·56
```

For the Departure.

As Merid. Diff. Lat. 113 to proper Diff. Lat. 64, ſo Diff. of Longitude 60 to Departure.

```
64
60
3840
```

```
113(3840(33 Dep. 33, or rather 34.
·450
111
```

CASE

CASE IV. *Both Latitudes and Diſtance given, to find the Courſe, Departure and Difference of Longitude.*

The RULE.

Find the Courſe and Departure, as in *Caſe* VI. of *Plane Sailing Arithmetical*, and then find Difference of Longitude, as in *Caſe* I. of *Mercator's Sailing Arithmetical.*

Queſtion. A Ship in Lat. 55d. 00m. North, ſails between the North and Eaſt 86 Miles, and then is by Obſervation in Lat. 56d. 10m. N. I demand as above.

See the ſame Queſtion in *Mercator's Sailing*, *Caſe* V.

For the Departure.

86		Sq. of Diſt. 7396	2496(49
86	70	Sq. of Dep. 4900	16
	70		
516		Diff. of Sq. 2496	89)896
688	4900		801
7396			95

For the Courſe.

86)70000(813
120
340
82

For the Difference of Longitude.

As 70 to 124, ſo 50 to Diff. Long.

50	70)6200(89$\frac{4}{7}$
6200	·600
	40

The Departure 50, the Courſe N.E. $\frac{1}{4}$ N. the Diff. of Longitude 89 $\frac{4}{7}$.

CASE

CASE V. *Both Latitudes and Departure given, to find the Courſe, Diſtance, and Difference of Longitude.*

The RULE.

Find the Courſe and Diſtaace, as in *Caſe* VI. of *Plane Sailing Arithmetical*; and Difference of Longitude, as in the firſt Caſe of *Mercator's Sailing Arithmetical.*

Queſtion. A Ship in Lat. 55d. 0m. North ſails between the North and Eaſt into Lat. 56d. 10m. North, her Departure 50 Miles; I demand the Courſe, Diſtance and Difference of Longitude.

For the Diſtance.

70	50	Sq. of Diff. Lat.	4900	7400(86
70	50	Square of Dep.	2500	64
4900	2500	Sum of Squares	7400	166)1000
				996
				004

For the Courſe.

86)70000(813
120
340
82

For Diff. of Long.

As 70 to 124, ſo 50 to Diff. of Long.

50
6200

70)6200(88$\frac{4}{7}$
60
40

The Courſe is N.E. $\frac{1}{2}$ N. the Diſtance 86; the Difference of Longitude 88 $\frac{4}{7}$, or rather 89.

CASE

CASE VI. *Both Latitudes and Difference of Longitude given, to find Courſe, Diſtance and Departure.*

The RULE.

Square the Difference of Longitude, and alſo Meridional Difference of Latitude, the Square Root of the Sum of theſe two Squares is the enlarged Diſtance: Then, as Merid. Diff. of Latitude to proper Diff. of Latitude, ſo the enlarged Diſtance to the true Diſtance: And then find the Courſe as in *Plane Sailing Arithmetical*, *Caſe* IV.

Queſtion. Suppoſe two Places, one in Lat. 56d. 15m. North, the other in Lat. 58d. 35m. their Diff. of Long. 2d. 30m. or 150 Min. I demand the Courſe and Diſtance from the Southermoſt to the Northermoſt.

For the Diſtance.

150	260
150	260
75	156
15	52
22500	67600

Sq. of Mer. Diff. of Lat. 67600
Sq. of Diff. of Long. — 22500
Sum of the Squares —— 90100

90100(300
9
60)001
000
600)100

As

As 260 to 140, *ſo* 300 to the Diſtance.

300	269)420000(161	*For the Courſe.*
	160	161)140000(869
4200	··400	1120
		1540
	140	
		091

The Diſtance 161. The Courſe N.N.W. ½ W.

CASE VII. *One Latitude, Courſe, and Departure given, to find the other Latitude, Diſtance, and Difference of Longitude.*

The RULE.

Find the Diſtance by *Caſe* III. of *Plane Sailing Arithmetical*, and the Difference of Latitude as in *Caſe* V. of the ſame; and Difference of Longitude as in all the other Caſes hereof.

Queſtion. A Ship in Lat. 58d. oom. North, ſails SSW. half W. till her Departure be 60 Miles; I demand as above.

For the Diſtance.	*For Diff. of Lat.*	
47)6000(127	127	60
130	127	60
360		
	889	3600
35	254	
	127	
	16129	

Square

Square of Diſtance ——	16129	12529(111
Square of Departure —	3600	1
Diff. of the Squares —	12529	21)025
		21
		221)429
		221
		208

For the Difference of Longitude.

As proper Diff. of Lat. 112, to Merid. Diff. Lat. 206, ſo Departure 60 to Diff. of Long.

206	112)12360(110
60	·116
12360	··40

The Difference of Latitude 112 Min. or 1d. 52m. which ſubtracted from the Latitude ſailed from, becauſe the Courſe is Southerly, the Remainder is the Latitude come to, 56d. 8m. the Diſtance 127; the Diff. Longitude 110.

CASE VIII. *One Latitude, Diſtance, and Departure given, to find the other Latitude, Courſe, and Difference of Longitude.*

The RULE.

Find the Courſe and Difference of Latitude as in *Caſe* V. of *Plane Sailing Arithmetical*; then find the Difference of Longitude as before.

Queſtion

Queſtion. A Ship in Lat. 58d. 00m. North, ſails between the South and Weſt 127 Miles, her Departure 60, I demand the reſt.

For the Difference of Latitude.

```
  127          Sq. of Diſt. — 16129      . . .
  127    60    Sq. of Dep. —  3600      12529(111
 ----    60                              1
  889   ----   Diff. of Square 12529    ----
  254   3600                           21)025
  127                                     21
 ----                                   ----
 16129                                  221)429
                                        ------
                                           208
```

For the Courſe.

```
127)60000(472
  ·920
  ·310
 ----
   56
```

For Difference of Longitude.

As 112 to 206, ſo 60 to Diff. Long.

```
   60
 ----
12360

112)12360(110
   ·116
 ------
  ··40
```

The Courſe S.S.W. ½ W. the Lat. come to 56d. 08m. and Diff. of Long. 110.

SECT.

SECT. III.

Parallel Sailing Arithmetical.

BEFORE I proceed to the Solution of the ſeveral Caſes of *Parallel Sailing*, I ſhall inſert a Table of given Numbers, which is equally uſeful in *Parallel* and *Middle Latitude Sailing*; for by thoſe Numbers the Departure in *Middle Latitude Sailing* (which is the Diſtance in a Parallel, or Eaſt and Weſt Courſe) is reduced to Difference of Longitude without any Logarithms, Sines or Tangents, only by one Operation in Diviſion, the Uſe of which Table in *Parallel Sailing* is thus:

When you have the Diſtance in the Parallel given, add ſo many Cyphers to the Diſtance as you intend to uſe Figures in the given Number, and then divide the one by the other, and the Quotient is the Difference of Longitude: But if Difference of Longitude, and the Latitude is given, multiply the Difference of Longitude by the given Number belonging to that Latitude, and from the Product cut off as many Figures as you multiply by, and the reſt is the Diſtance; and conſequently if Diſtance and Difference of Longitude be given, and Latitude required, add two, three or four Cyphers to the Diſtance, and divide that Sum by the Difference of Longitude, the Quotient found in the Table is the given Number, anſwering to the Latitude required, *&c.*

A TABLE

A TABLE of given Numbers for Parallel and Middle Latitude; the given N° for Lat ood. oom. being 10000.

Lat.	N°	Diff.	Lat.	N°	Diff.	Lat.	N°	Diff.
1	9998	. . .2	31	8572	. . 88	61	4848	. 152
2	9994	. . .4	32	8480	. . 91	62	4695	. 153
3	9986	. . .7	33	8387	. . 93	63	4450	. 155
4	9976	. . 10	34	8290	. . 96	64	4384	. 156
5	9962	. . 14	35	8191	. . 99	65	4226	. 158
6	9945	. . 17	36	8090	. 101	66	4067	. 159
7	9925	. . 20	37	7986	. 104	67	3907	. 160
8	9902	. . 23	38	7880	. 106	68	3746	. 161
9	9877	. . 26	39	7771	. 109	69	3584	. 162
10	9848	. . 29	40	7660	. 111	70	3420	. 163
11	9816	. . 32	41	7547	. 113	71	3256	. 164
12	9781	. . 35	42	7431	. 116	72	3090	. 165
13	9744	. . 37	43	7313	. 118	73	2924	. 166
14	9703	. . 41	44	7193	. 120	74	2756	. 167
15	9659	. . 44	45	7071	. 122	75	2588	. 168
16	9613	. . 47	46	6946	. 124	76	2419	. 169
17	9563	. . 50	47	6820	. 126	77	2249	. 170
18	9511	. . 53	48	6691	. 129	78	2079	. 170
19	9455	. . 56	49	6560	. 131	79	1908	. 171
20	9397	. . 59	50	6416	. 133	80	1736	. 172
21	9334	. . 62	51	6293	. 135	81	1564	. 172
22	9272	. . 65	52	6157	. 137	82	1392	. 172
23	9205	. . 67	53	6018	. 139	83	1219	. 173
24	9135	. . 70	54	5878	. 141	84	1045	. 174
25	9063	. . 72	55	5735	. 143	85	0871	. 174
26	8988	. . 75	56	5592	. 144	86	0697	. 174
27	8910	. . 78	57	5446	. 146	87	0523	. 174
28	8829	. . 81	58	5299	. 147	88	0349	. 174
29	8746	. . 83	59	5150	. 149	89	0175	. 174
30	8660	. . 86	60	5000	. 150	90	0000	. 175

The

The Uſe of this Table of given Numbers for *Parallel* and *Middle Latitude Sailing*, is partly laid down in the Page preceding the Table, and ſhall be further exemplified in the ſeveral Caſes of *Parallel* and *Middle Latitude Sailing*; and the ſame Cautions are to be obſerved in the Uſe of this, that was to be obſerved in the firſt Table of given Numbers, *viz.* that for *Plane Sailing Arithmetical*; for if the third Figure of the given Number be a Cypher, or 1 or 2, you need uſe but two Figures (unleſs your Queſtion be propoſed in very great Numbers;) or if the third Figure be 8 or 9, you may add one to the ſecond Figure, and ſo proceed in your Work: But in this Table, as alſo in that of *Plane Sailing*, if your Queſtion be propounded in Numbers conſiſting of three or four Figures, it is beſt to uſe at leaſt as many Figures of the given Number, as there is in the *Data*, or given Terms of your Queſtion, as we ſhall make evident by the ſucceeding Examples.

I have ſet down the given Numbers, only to whole Degrees of Latitude; the Numbers to the intermediate Minutes being eaſily found by proportioning the Differences ſet down in the third, ſixth, and ninth Columns of the Table, the Uſe of which is this: Suppoſe in a Parallel Courſe, the Latitude of the Parallel (or in a *Middle Latitude* Queſtion, the *Middle Latitude*) be 62 Degrees, and I deſire to find in the Table the given Number to that Latitude; I look in the Table under [*Lat.*] and find 62, and againſt it, under [*Num.*] you find 4695, the given Number required: But if you would find the given Number for Lat. 59d. 30m. I look for the Number for Lat. 60, and find 5000, and it being a Latitude between 59 and 60, I look againſt 60, under [*Diff.*] for the Difference, (for the Difference between the given Numbers for both Latitudes is always againſt the greater Latitude) and the Difference is 150, therefore I take Half of 150, becauſe 30 Minutes is half a Degree, and add it to the given Number for 60 Degrees, *viz.* 5000, the Sum 5075 is the given Number for the Lat. 59d. 30m. which was required to be known.

Note; The given Number for Lat. od. om. is 10000, and from thence, as the Latitude encreaſes, the Numbers decreaſes, ſo that the Number for Lat. 90 is 0000; hence the greater the Latitude is, the leſſer is the given Number; therefore obſerve always when you would find the Number to any Latitude conſiſting of Degrees and Minutes, take the given Number to the bigger Latitude, and to that add the Proportional Part of the Difference found againſt the bigger Latitude, the Sum is the given Number required. One Example will make it plain.

Suppoſe I deſire to know the given Number for Latitude 45d. 40m. the Number for 46 (the bigger Latitude) is 6946, and the Difference 124; one Third of which, *viz.* 41 neareſt, added to the Number 6946, the Sum 6987 is the Number required.

But if you want the given Number to any odd Minutes, which is not an even Part of a Degree, as half, for a third, *&c.* you may find it by Proportion if you would be very exact, or if your Queſtion be given in great Numbers, and the Proportion is, As 60 Min. to the whole Difference, ſo the Minutes, which the given Latitude wants of the bigger Latitude, to the Number to be added to the given Number of the bigger Latitude.

I deſire to know the given Number for Latitude 43d. 24m.

The Latitude 43d. 24m. wants 36 Min. of 44 Deg. therefore, as 60 to the Difference 120, ſo 36 to 72; which added to 7193, the given Number for the bigger Latitude, the Sum 7265 is the Number for Lat. 43d. 24m. required.

Note; If you uſe all the four Figures of the given Number, the Difference is as it is expreſſed in the Table; but if you cut off one Figure or two, *&c.* from the given Number to the Right-hand, you muſt alſo cut off as many from the Difference, and the Remainder is the Difference; only if the laſt Figure of the Difference be 8 or 9, you may add one to the third Figure, as in other Caſes before mentioned; the Reaſon is evident to them that underſtand Decimals

Example.

Example. I desire to know the given Number for Latitude 69d. 45m. I cut off one Figure to the Right-hand of each collateral Number, *viz.* Latitude 69, and Latitude 70, and then the Numbers are 358 and 342: And seeing I cut off a Figure from the Number, I must also cut one off from the Difference, and then the Difference is 16, which used according to the foregoing Rules, the given Numbers for Latitude 69d. 45m. will be found to be 346, and so in others.

CASE I. *Two Ships or Places in one Parallel, their Latitude and Distance given, to find their Difference of Longitude.*

The RULE.

Add so many Cyphers to the Distance as you think to use Figures in the given Number, and divide by the given Number for the Latitude of the Parallel, the Quotient is the Difference of Longitude.

Question. Two Ships in Latitude 50d. om. distant 76 Miles; I demand their Difference of Longitude.

The given Number for Latitude 50 is 6428, but if I cut off one Figure to the Right-hand, it will be 642; but because the last Figure, *viz.* that to the Right-hand, which I cut off, is 8, I add one to the third, and then it will be 643; and because I use three Figures of the given Number, I add three Cyphers to the Distance, and then divide one by the other, according to the aforesaid Rule, and the Work will stand thus:

643)76000(118 The Diff. of Long. 118 Min or 1d. 58m.
1170
5270
126

Or if I cut off two Figures, the reſt to work with will be 64, and then I add but two Cyphers to the Diſtance (becauſe I uſe but two Figures of the given Number) and the Work will ſtand thus:

64)7600(118 — The ſame with the foregoing Operation
120
560
48.

CASE II. *Two Places in one Parallel and Latitude, and Difference of Longitude given, to find their Diſtance.*

The RULE.

This is only the former Caſe inverted; for having found the given Number for the Latitude, multiply the Difference of Longitude by it, and from the Product cut off as many Figures as you multiply by, and the reſt is the Diſtance required; and thoſe cut off are a Decimal Fraction to be underſtood as in the Rules laid down at the Beginning of *Plane Sailing Arithmetical.*

Queſtion. Two Places in Latitude 50, their Difference of Longitude 118; I demand their Diſtance.

643
118
5144 The Diſtance 75.874, or rather 76.
643
643
75|874

CASE

CASE III. *Two Places, their Diſtance and Difference of Longitude given, to find the Latitude they are in.*

The RULE.

Add three or four Cyphers to the Diſtance, and divide that Sum, by the Difference of Longitude, the Quotient is the given Number for the Latitude required.

Queſtion. A Ship ſails due Weſt 27000 Miles, and then finds her Difference of Longitude to be 4200 Min. I demand what Latitude the Ship is in?

```
4200)2700000(642
     180
      12000
      ------
       3600
```

By adding three Cyphers to the Diſtance, and working as before directed, you find the Quotient 642; or if you add four Cyphers, it will bring out four Figures in the Quotient, *viz.* 6428, which found in the Table, you find it againſt Latitude 50, which is the Latitude of the Parallel required.

CASE IV. *Two Ships ſailing directly North or South, thier Diſtance in one Parallel given, to find their Diſtance in the other Parallel.*

The RULE.

Find the given Numbers for each Latitude, and ſay by the Rule of Three: As the given Number for the firſt Latitude to the given Number for the ſecond Latitude, ſo the Diſtance in the Latitude to the Diſtance in the ſecond Latitude.

Queſtion. Suppoſe two Ships in Lat. 50, diſtant 200 Miles, ſail both directly North into Lat. 73d. om. I demand their Diſtance in that Parallel.

Here we ſhall uſe but the two firſt Figures of the given Numbers, becauſe the third Figure in each Number is but ſmall, *viz.* 2: And then by the foregoing Rule,

As 64 to 29, ſo 2000 to the Diſtance in Lat. 73.

29	64)5800(90
2|00	40
5800	

Their Diſtance in Latitude 73, is 90 $\frac{40}{64}$, or (if you will avoid Fractions) 91 Miles.

CASE V. *Two Ships in one Parallel, with their Diſtance in that Parallel given, and ſailing both directly North or South, with their Diſtance in the Parallel ſailed, given, to find the Latitude come to.*

The RULE.

This is only the former Proportion (in *Caſe* IV.) inverted, *viz.* As Diſtance in one Latitude to the Diſtance in the other Latitude, ſo the given Number for one Latitude to the given Number for the other Latitude.

Queſtion. Two Ships in Lat. 50, diſtant 200 Miles, ſail both directly North, till they are but 91 Miles diſtant; I demand the Latitude come to?

As 200 to 91, ſo 64 to the given Number for the Latitude come to.

91	
64	200)5824(29
364	182
546	24
5824	

The Quotient 29 is the two firſt Figures of the given Number for the Lat. come to, *viz.* Lat. 73d. om.

SECT. IV.

Middle Latitude Sailing Arithmetical.

IN Working the ſeveral Caſes and Queſtions of *Middle Latitude Sailing*, we ſhall have Occaſion to make Uſe of both the Tables of given Numbers; for in all Caſes or Varieties, where the Courſe, Diſtance, Difference of Latitude, and Departure, are Terms either given or required, the Operation is performed by the firſt Table, as in *Plane Sailing*; but when Difference of Longitude is a Term in the Queſtion, (whether given or required) the ſecond Table is of Uſe, as will appear by the following Examples.

CASE I. *One Latitude, Courſe, and Diſtance given, to find the other Latitude, Departure, and Difference of Longitude.*

The RULE.

By Courſe and Diſtance find Difference of Latitude and Departure, (and conſequently the other Latitude) as in *Caſe* I. of *Plane Sailing Arithmetical*; and then for the Difference of Longitude, it is found by the ſecond

Table thus: Find the given Number for the Middle Latitude, of which you may uſe two or three, or four Figures, according to the Rules laid down at the Beginning of *Plane Sailing*, and alſo at the Beginning of *Parallel Sailing Arithmetical*; then to the Departure add ſo many Cyphers to the Right-hand, as you intend to uſe Figures in the given Number; that Sum divided by the given Number, the Quotient is the Longitude required.

Queſtion. A Ship in Lat. 50d. 00m. North, ſails N.W. by N. 987 Miles: I demand the Latitude come to, with Departure, and Difference of Longitude.

For the Difference of Latitude and Departure by the firſt *Caſe* of *Plane Sailing Arithmetical.*

For Diff. of Lat.	*For the Departure.*
987	987
83	556
2961	5922
7869	4935
819|21	4935
	548|772

Although the three firſt Figures of the given Number to find your Departure for that Courſe be 555, yet the laſt Figure being 6, I cut it off and add 1 to the third Figure, and call it 556, as in the Operation above, and ſo the Difference of Latitude is 819, or rather 820, and the Departure 549, allowing one for the Fraction,

Then for the Difference of Longitude.

The Diff. of Latitude being 820 Min. or 13d 40m. the Latitude come to is 63d. 40m. and conſequently the Middle Latitude is 56d. 50m. the given Number for that Latitude

Latitude (found by the Rules laid down in the Beginning of *Parallel Sailing*) is 5470; but the laſt Figure being a Cypher, I cut it off, and work with the reſt, as in the Rule above, and the Operation ſtands thus:

547)549000(1003
··2000
359

The Difference of Longitude is 1003 Min. or 16d. 43m. Weſt.

CASE II. *Both Latitudes and Courſe given, to find the Departure, and the Difference of Longitude.*

The RULE.

Find the Diſtance and Departure, as in Caſe the ſecond of *Plane Sailing Arithmetical*, and then find the Difference of Longitude, as in the firſt Caſe of *Middle Latitude Sailing Arithmetical.*

Note; In *Middle Latitude Sailing Arithmetical*, this Way of finding the Longitude anſwers in all the Caſes thereof, and therefore I ſhall not need to mention it in the reſt of the Caſes.

Queſtion. A Ship takes her Departure from a Port in Latitude 56d. 25m. North, and ſails N.N.E. till ſhe finds herſelf to be by Obſervation in Latitude 68d. 30m. North; I demand the Diſtance ſailed, with her Departure, and Difference of Longitude.

The Difference of Latitude is 12d. 05m. or 725 Min.

For the Diſtance.

924)725000(784
·7820
·4280
684

For the Departure.

785
383
2355
6280
2355
300|655

Th

The Middle Latitude 62d. 28m.
The given Number for 62d. 28m. is 4622

Then for the Difference of Longitude.

462)301000(651
2380
··700
238

The Diff. 785; the Departure 301; the Diff. of Longitude 651 Min. or 10d. 51m.

CASE III. *Both Latitudes and Difference given, to find the Courſe, Departure and Difference of Longitude.*

The RULE.

Find the Courſe and Departure, as in *Caſe* IV. of *Plane Sailing Arithmetical*, and the Difference of Longitude, as in other Caſes hereof.

Queſtion. A Ship in Lat. 55d. 00m. ſails between the North and Eaſt 86 Miles, and then finds herſelf by Obſervation in Lat. 56d. 10m. her Courſe, Departure, and Difference of Longitude, is required.

For the Departure by the Square Root.

86	70	Square of the Diſtance	7396
86	70	Square of the Departure	4900
516	4900	Diff. of the Squares	2496
688			
7396			

2496

2496(49
16
89)896
801
95

The Departure 50 neareſt, becauſe the Fraction is more than the Root by the general Rule in *Caſe* V. of *Plane Sailing Arithmetical.*

For the Difference of Long.

The Midd. Lat. is 55d. 35m.
The given Number 5652.
555)50000(88
4800
280

For the Courſe.

86)70000(813
120
340
82

The Departure 50; the Courſe N.E. ¼ N. and the Difference of Longitude 88 ½ *fere.*

CASE IV. *Both Latitudes and Departure given, to find the Courſe, Diſtance and Difference of Longitude.*

The RULE.

Find the Courſe and Diſtance by *Caſe* VI. of *Plain Sailing Arithmetical*; and Longitude as in the other Caſes.

Queſtion. A Ship in Lat. 55d. 0m. North, ſails between the North and Eaſt into Lat. 56d. 10m. North, her Departure 50 Min. or Miles, the Courſe, Diſtance and Difference of Longitude are required.

The Difference of Latitude is 70 Miles.

		For the Diſtance of the Square Root.		
70	50	Square of Diff. Lat.	4900	7400(86
70	50	Square of Dep. —	2500	64
4900	2500	Sum of Squares —	7400	166)1000
				996
				004

For

For the Courſe.

86)70000(813
120
340
82

For the Diff. of Long.

The Mid. Lat. 55d. 35m.
The given Numb. 5652

565)50000(88
4800
280

The Diſtance 86; the Courſe N.E. ¼ N. the Diff. of Longitude 81 ¼ Min. or 1d. 28m. Eaſt.

CASE V. *Both Latitudes and Difference of Longitude given, to find Courſe, Diſtance, and Departure.*

The RULE.

In all Caſes where the Difference of Longitude is given, and Departure required, the Operation is but the Inverſe of that for finding Difference of Longitude when Departure is given; for if the Departure, with Cyphers added to the Right-hand, and divided by the given Number for the Middle Latitude, produce the Difference of Longitude; then the Difference of Longitude, multiplied by the given Number for the Middle Latitude, muſt needs produce the Departure, with Figures to be cut off; becauſe any Quotient multiplied by the Diviſor produceth the Dividend; therefore, to find the Departure in this Caſe, multiply the Difference of Longitude by the given Number for the Middle Latitude, and from the Product cut off as many Figures to the Right-hand as you multiply by, and the reſt is the Departure; thus having the Difference of Latitude and Departure, find the Courſe and Diſtance, as in *Caſe* VI. of *Plane Sailing Arithmetical.*

Queſtion.

Queſtion. I demand the Courſe, Diſtance and Departure between two Places, one in Lat. 56d. 15m. North, the other in Lat. 58d. 35m. North, their Difference of Longitude 150 Min. or 2d. 30m.

For the Departure.

The Middle Latitude being 57d. 25m. and the given Number 5384.

5384
150

269200
5384

80|7600

For the Courſe.

161)14000(869
·1120
·1540
··91

For the Diſtance by the Square Root.

140	81	Sq. of Diff. Lat	19600
140	81	Square of Dep.	6561
5600	81	Sum of Squares	26161
140	648	. . .	
19600	6561	26161(161	
		1	
		26(161	
		156	
		321)561	
		321	
		240	

The Diſtance is 161; the Departure 80 $\frac{7}{8}\frac{6}{8}$, or (to avoid Fractions) 81; the Courſe 2 $\frac{1}{4}$ Points to the Eaſtward or Weſtward of the North or South, according to the Denomination of the Longitude, whether Eaſt or Weſt.

Theſe

Theſe being the moſt uſeful Caſes, I ſhall (as in *Middle Latitude Sailing Trigonometrical*) ſet down only the *Data* and *Quæſita* of the reſt, with Rules for working them, and leave the Operation for the Learner's Practice.

CASE VI. *One Latitude, Courſe, and Departure given, to find the other Latitude, Diſtance, and Difference of Longitude.*

The RULE.

Find the Diſtance and Difference of Latitude, (and conſequently the other Latitude) by *Caſe* III. of *Plane Sailing Arithmetical*, and Difference of Longitude as in the other Caſes.

CASE VII. *One Latitude, Diſtance and Departure given, to find the reſt.*

The RULE.

Find the Courſe and Difference of Latitude, by *Caſe* V. of *Plane Sailing Arithmetical*, and Difference of Longitude as before.

CASE VIII. *Courſe, Departure and Difference of Longitude given, to find both Latitude and Diſtance.*

The RULE.

Find Diſtance and Difference of Latitude by *Caſe* III. of *Plane Sailing Arithmetical*; then divide the Departure (with Cyphers added on the Right-hand) by the Difference of Longitude, the Quotient is the given Number for the Middle Latitude, conſiſting of as many Figures as you added Cyphers; and the Middle Latitude, and Difference of Latitude, thus given, or found, the other Latitude is eaſily found; but becauſe Departure and Difference of Longitude given, to find Middle Latitude, (and conſequently both Latitudes) is a Variety that we have not

not had an Example in, I ſhall inſtance in one Queſtion for the Reader's Practice.

Queſtion. A Ship ſails N.N.E. till her Departure be 301, and Difference of Longitude 651; I demand both Latiudes and Diſtance?

For the Diſtance.

383)301000(785
·329
·2260
345

For Diff. Lat. by the Square Root.

785
785
3925
6280
5495
616225

301
301
301
9030
90601

Square of the Diſtance —— —— 616225
Square of the Departure —— —— 90601

Difference of the Squares —— —— 525624

For the Middle Latitude

651)301000(462
4060
1540
238

525624(724
49
142)356
284
1445)7224
5780
1444

The Number 462 is the three firſt Figures of the given Number for the Middle Latitude, which anſwer to Latitude 62d. 28m. then half the Difference of Latude added to, and ſubtracted from the Middle Latitude, gives the two Latitudes, 56d. 25m. and 68d. 30m. and the Diſtance is 785.

Note;

Note; Although the Difference of Latitude comes out but 724, yet the Fraction is ſo great that if the Number had been but one Unit more, the Root had been 725.

CASE IX. *Middle Latitude, Courſe and Diſtance given, to find both Latitudes, Departure and Difference of Longitude.*

The RULE.

By Courſe and Diſtance to, find Difference of Latitude and Departure, by *Caſe* I. of *Plane Sailing Arithmetical*, and then find Difference of Longitude, as in other Caſes.

CASE X. *Courſe, Diſtance, and Difference of Longitude given, to find both Latitude and Departure.*

The RULE.

Find Difference of Latitude and Departure by *Caſe* I. of *Plane Sailing Arithmetical*, and then find Middle Latitude, and conſequently both Latitudes, by *Caſe* VIII. hereof.

CASE XI. *Courſe, Difference of Latitude, and Difference of Longitude given, to find both Latitudes, Diſtance and Departure.*

The RULE.

Find the Diſtance and Departure by *Caſe* II. of *Plane Sailing Arithmetical*, and then find Middle Latitude, and thereby both Latitudes by *Caſe* VIII. hereof.

CASE

CASE XII. *Middle Latitude, Courſe and Difference of Longitude given, to find both Latitudes, Diſtance and Departure.*

The RULE.

For the Departure, multiply the Difference of Longitude by the given Number for the Middle Latitude, and from the Product cut off as many Figures to the Right-hand as you multiply by, and the reſt is the Departure; and thus having the Courſe and Departure, you may find the Diſtance and Difference of Latitude, and, (by the Help of Middle Latitude) both Latitudes by *Caſe* III. of *Plane Sailing Arithmetical.*

CASE XIII. *One Latitude, Departure, and Difference of Longitude given, to find the other Latitude, Courſe, and Diſtance.*

The RULE.

Find the Middle Latitude by *Caſe* VIII. hereof, and then having one Latitude, and Difference of Latitude, the other Latitude is eaſily found; and thus having both Latitudes and Departure, find Courſe and Diſtance by *Caſe* VI. of *Plane Sailing Arithmetical.*

And thus I have gone thro' the thirteen Caſes of *Middle Latitude Sailing Arithmetical*, where in the firſt five Caſes, in which there are Queſtions propoſed and wrought, I have ſet down the very ſame Queſtions here that are in *Middle Latitude Sailing Trigonometrical*, that the Reader may ſee the exact Harmony between the *Trigonometrical* and *Arithmetical Operations*, and conſequently may be convinced of the Truth and Certainty of this Way of working, ſo far as *Middle Latitude Sailing* is to be depended upon; and although *Middle Latitude Sailing* deviates ſomewhat from *Mercator*, eſpecially at a great Diſtance from the Equinoctial, or where the Queſtion is propoſed in great Numbers, yet it may be of great Uſe, in keeping a Reckoning; becauſe, in a ſingle Day's Work (which ſeldom exceeds 30 or 40 Leagues) the Difference is ſcarce diſcernable; and al-

ways obſerve, that if through Haſte you cannot take Time to reckon the Middle Latitude exactly to a Minute, take rather a Latitude too great than too little for Middle Latitude, and that will leſſen the Error, as I hinted in *Middle Latitude Sailing Trigonometrical, Caſe* I.

CHAP. V.

Inſtrumental Navigation.

SECT. I.

Plane Sailing Inſtrumental.

MY Intent in this Section of *Inſtrumental Navigation*, is not to write a large Treatiſe of all the Inſtruments that are uſeful in Navigation, for that would take up too large a Part in this ſmall Treatiſe; but I ſhall here ſhew, how all the Propoſitions in *Plane Sailing*, *Mercator*, &c. (which are in other Parts of this Treatiſe ſolved *Geometrically*, *Trigonometrically*, *Arithmetically*, &c.) may be ſolved *Inſtrumentally*, *viz.* by Scale and Compaſſes; and here I ſhall confine my ſelf only to the Uſe of *Gunter's Scale*, it being an Inſtrument ſo common and expeditious for Inſtrumental Operation, that few that are inclined to improve themſelves in the Knowledge of Navigation, go to Sea without it. In order to the right Underſtanding of which, it is neceſſary,

ceſſary, firſt, to give a Deſcription of that Part of the Scale which ſerves for our preſent Purpoſe, and then proceed to the Uſe of it.

The firſt Line next the Top, commonly marked *S.R.* is the Sine Rumbs, and is numbered 1, 2, 3, 4, 5, 6, 7, and ends at the Braſs Nail with 8, which is Radius, becauſe 8 Rumbs or Points of the Compaſs, is a Quarter of the whole Circle, and therefore equal to 90 Degrees.

The next Line marked *T.R.* is the Tangent Rumb, and this Line is numbered 1, 2, 3, and then at the Braſs Nail 4, the Tangent of 4 Points, or 45 Degrees, being equal to Radius, and then proceed back towards the Left-hand with 5, 6, 7, the Tangent of 8 Points, or 90 Degrees being infinite.

Theſe Sine Rumbs and Tangent Rumbs, are only uſeful in Navigation. The Sine Rumb, or Tangent Rumb, being only the Sine or Tangent of the Degrees and Minutes anſwering to thoſe Rumbs: Thus, becauſe 1 Point of the Compaſs contains 11d. 15m. therefore the Sine of 1 Point is equal to the Sine of 11d. 15m. *&c.* Alſo three Points are 33d. 45m. therefore the Sine of 3 Points, in the Sine Rumbs, is exactly againſt the Sine of 33d. 45m. in the Sines, and the Tangent of 3 Points is right againſt the Tangent of 33d. 45m. *&c.*

The next Line being the third in order, marked [*Numb.*] is the Line of Numbers, which is numbred from the Left-hand with 1, 2, 3, 4, 5, 6, 7, 8, 9; 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. The Diviſions at 1, 2, *&c.* being the greateſt, and growing leſs towards 9, *&c.* Theſe Diviſions being divided each into 10 Parts, and every one of theſe again ſubdivided (where Room will permit) into 10 Parts, and are thus read: If you call 1 at the Left-hand 1, then the next 2 is 2, and ſo on 3, 4, 5, *&c.* to 9, and the 1 on the Middle is 10, and the next 2, 3, 4, *&c.* is 20, 30, 40, *&c.* and the 10 at the Right-hand is 100, and thus when 1 in the Middle is 10, and the 2 is 20, *&c.* then every one of the 10 leſſer Diviſions between 1 and 2 is 1: Thus 1 being 10, the next ſmaller Diviſion is 11, and the next 12, where there is commonly a Braſs Nail, and ſo on, to 13, 14,

15, *&c.* till you come at the 2 for 20, and 3 for 30, and ſo in the reſt.

But if you make 1 at the Left-hand 10, then 1 in the Middle is 100, and 10 at the Right-hand is 1000, and then every of the leſſer Diviſions, which before was reckoned 1, is now reckoned 10, *&c.* Thus the 1 at the Middle being 100, the next ſmall Diviſion (which before was called 11) is now 110, and the next where the Braſs Nail is, 120, *&c.* and then every one of the ſmalleſt Subdiviſions is called 1. Thus ſuppoſe I would find 125, on the Scale I call 1, in the Middle, (or at the Left-hand) 100; and counting 2 of the ſmall Diviſions further (which is juſt at the Braſs Nail) and then 5 of the ſmalleſt Subdiviſions, there I hold my Compaſſes, it being the Number required; a little Practice will make it eaſy.

The next Line is the Sines marked at the Right-hand [*Sines*] and numbred from the Left-hand, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, the longer, Subdiviſions between 10 and 20, and between 20 and 30, *&c.* being each 1 Degree; but the Degrees under 20 are ſubdivided into 6 Parts, each Part being 10 Minutes; and where the Degrees are divided into 4 Parts, each Part is 15 Min. *&c.* Thus ſuppoſe I ſeek the Sine of 23d. 30m. firſt I find 20, and then count 3 of the bigger Subdiviſions which are 23; and then 2 of the ſmalleſt Subdiviſions for 30 Min. (becauſe the Degree is divided into 4 Parts) and that is the Point repreſenting the Sine of 23d. 30m. where there is commonly a Braſs Nail, as at 12 on the Line of Numbers.

The next Line is Verſed Sines marked [*V. Sines*] of which there is ſeldom Uſe made in Navigation.

The next is Tangents, marked at the Right-hand [*Tang.*] they proceed from the Left-hand to the Right, from 1 to 45, and then back to the Left-hand towards 90, the Subdiviſions are underſtood in all Reſpects, as thoſe of the Line of Sines, and therefore need be no further explained.

By this Scale, and a Pair of Compaſſes, may be performed all the Propoſitions in *Trigonometry* and *Navigation*, in all their Parts. As they are ſolved elſewhere

In

in this Treatiſe by Geometrical Conſtruction, and by Arithmetical Calculation, ſo here I ſhall ſhew how they may be ſolved by Inſtrumental Operation; and here, whatever the Queſtion be, the Proportion for anſwering it is the ſame as in *Trigonometry*, by Logarithms, Sines and Tangents; only whereas in Natural Numbers, the Operation is performed by Multiplication and Diviſion, (where three Numbers are given to find a fourth) and in Logarithms it is done by Addition and Subtraction; ſo here it it performed by taking in your Compaſſes the Diſtance upon the Scale, between the firſt and ſecond given Terms, and the ſame Extent will reach from the third given Term to the fourth Term required; but becauſe, if the ſecond Term have the ſame Proportion to the firſt, that the fourth hath to the third, then the third will have the ſame Proportion to the firſt that the fourth hath to the ſecond, by *Euclid*, *Lib.* 5. *Prop.* 16. and therefore when the firſt and third Terms are both of one Denomination, *viz.* both Snes, or both Tangents, or both Numbers, as it happens in moſt Queſtions in Navigation, and where the ſecond and fourth are alſo of one Denomination, I would rather adviſe to extend from the firſt to the third, and by that Means you keep along one Line, whether Sines, Tangents, or Numbers; and then the Proportion and Anſwers will come out the ſame, as by Trigonometrical Calculation.

And becauſe the Proportions in this Manner of working are the ſame as in the Logarithmetical Operations, I ſhall not be at the Pains of running over all the particular Caſes of *Plane Sailing* and *Mercator*, *&c.* as in the *Geometrical* and *Trigonometrical* Parts hereof; but ſhall only inſtance in ſome few Queſtions, and thereby ſhew the Learner how all the reſt may be deduced from the Proportions elſewhere laid down in the *Trigonometrical* Part.

Example in Plane Sailing.

CASE I. *Courſe and Diſtance given, to find the Difference of Latitude and Departure.*

A Ship ſails N.W. by N. 123 Miles; I demand her Difference of Latitude and Departure.

Firſt, For the Difference of Latitude.

You may obſeve in the *Trigonometrical* Part, that the Proportion is, As Radius to the Diſtance, ſo Sine Complement of the Courſe to Difference of Latitude; therefore here the Courſe being N.W. by N. that is, three Points from the Meridian, its Complement is five Points; therefore extend on the Sine Rumbs from Radius (the Braſs Nail at the End) to five Points; the ſame Extent will reach on the Line of Numbers from 123 to 102, the Difference of Latitude required.

Then for the Departure.

The Proportion in *Trigonometry* is, As Radius to Diſtance, ſo Sine of the Courſe to Depature; therefore extend from Radius to 3, on the Sine Rumbs, the ſame Extent will reach from the Diſtance 123 (on the Line of Numbers) to 68, the Departure required.

Note; The ſame may be performed on the Line of Sines; for if you extend from Radius to Sine of 33d. 45m. (the Courſe reckon'd in Degrees and Minutes, allowing 11d. 15m. to a Point) the ſame Extent will reach on the Line of Numbers from the Diſtance 123 to the Departure 68, as before; and for Difference of Latitude, extend from Radius, to Sine Complement of the Courſe, 56d. 15m. the ſame Extent will reach from the Diſtance 123, to the Difference of Latitude 102, and ſo in others.

Thus in *Plane Sailing*, *Caſe* II. where the Courſe and Difference of Latitude is given, to find the Diſtance and Departure

Departure, you ſee in the *Trigonometrical* Part, that the Proportion for finding the Diſtance is, as Sine Complement of the Courſe, to the Difference of Latitude, ſo Radius to the Diſtance; therefore extend from Sine Complement of the Courſe to Radius, the ſame Extent will reach from the Difference of Latitude to the Diſtance.

Example. A Ship ſails S. W. by S. till her Difference of Latitude be 174 Miles; I demand her Diſtance and Departure.

Firſt, For the Diſtance.

Extend from 5 on the Sine Rumbs (or from 56d. 15m. on the Sines) the Complement of the Courſe, to Radius: The ſame Extent will reach from the Difference of Latitude 174, to the Diſtance 209; then for the Departure the Proportion is, As Sine Complement of the Courſe to Difference of Latitude, ſo Sine of the Courſe to the Departure: Therefore extend from Sine Complement of the Courſe 5 on the Sine Rumbs, (or 56d. 15m. on the Sines) to the Sine of the Courſe 3 on the Rumbs, (or 33d. 45m. on the Sines) the ſame Extent will reach on the Line of Numbers from the Difference of Latitude 174, to the Departure 116.

In the like Manner are all the Caſes in *Plane Sailing* and *Mercator* performed on the Scale, if you do but know the Proportions, (which you have at large in the *Trigonometrical* Part) and therefore I need not enlarge any further upon it; only this is to be obſerv'd, that you muſt mind always to extend your Compaſſes the ſame Way (whether backwards or forwards) at the laſt Extent that you do at the firſt; that is, if your Extent from the firſt Number to the ſecond be from the Left-hand towards the Right, then your fixed Point being placed at the third Number; the moveable Point muſt be extended towards the Right-hand alſo, and the contrary, unleſs in caſe you have to extend from a Tangent above 45, becauſe they increaſe from the Right-hand towards the Left (as hath been ſaid before) of which you have

ſometimes Occaſion to make uſe, in Caſe VI. of *Plane Sailing*; as for Example.

A Ship ſails between the South and Weſt till her Difference of Latitude be 80, and her Departure 95; I demand her Courſe and Diſtance.

The Proportion being, As Difference of Latitude to Radius, ſo Departure to Tangent of the Courſe; therefore extend from Difference of Latitude 80, to the Departure 95, (which is towards the Right-hand, becauſe increaſing, *viz.* 95 is more than 80;) the ſame Extent will reach from Radius to the Tangent of the Courſe 50; and although Radius is at the End of the Line, ſo that you cannot extend any further towards the Right-hand, yet in your extending towards the Left-hand, you muſt count the Degree that the Compaſs Point falls upon, on thoſe Degrees which are increaſing above 45 towards the Left-hand; thus in this Caſe, you find the moveable Point of the Compaſs fall upon a Stroke marked 40 50, *viz.* it is either the Tangent of 40 or of 50; but the Extent from 80 to 95 being towards the Right-hand increaſing, and your fixed Point being placed in the ſecond Extent at Radius, *viz.* Tangent of 45, you muſt account the ſecond Extent alſo increaſing, and the Tangent that is above 45, *viz.* 50, is the Anſwer to your Queſtion; and this (with the Help of *Plane Sailing Trigonometrical* for finding the Proportions, till you have them by heart) may be ſufficient for *Plane Sailing Inſtrumental.*

SECT. II.

Mercator's Sailing Inſtrumental.

IN *Mercator's Sailing*, as well as in *Plane Sailing*, the Proportions are the ſame as in the *Trigonometrical* Part, and may be learned in *Mercator's Sailing Trigonometrical*; but becauſe my Deſign is to ſhew how all the Caſes

Caſes hereof may be ſolved by Scale and Compaſſes, without Tables; I ſhall firſt ſhew how the Meridional Difference of Latitude may be found by the Scale and Compaſſes, both Latitudes being firſt given or found.

There is upon the Scale two other Lines, beſides what we have yet ſpoken of, which are next the lower Edge of the Scale; the firſt of them next the Tangent Line, is the Meridian Line, marked [*Merid.*] and the next and loweſt is a Line of equal Parts, marked [*Eq. P.*] theſe are of Uſe for graduating a *Mercator*'s Chart (of which more elſewhere in this Book) and alſo for finding the Meridional Difference of Latitude. The Equal Parts are Degrees of the Equinoctial, and every Diviſion or Degree contains 60 Miles, or Minutes; and hence every 10 Degrees marked 10, 20, 30, *&c.* contains 600 Miles; but the Degrees of Latitude growing larger towards the Poles, in a *Mercator*'s Chart, for holding the ſame Proportion to the Degrees of Longitude that they do upon the Globe, every Degree nearer the Pole, contains ſo many more Meridional Miles, according as the Degrees of Latitude upon the Meridional Line grow larger, as the Latitude increaſes; hence, to find the Meridional Difference of Latitude, when the two Latitudes are given or found, extend the Compaſſes between the two given Latitudes on the Meridional Line; which done, apply the ſame Extent to the equal Parts, and accounting every 10 Degrees 600 Miles, every Degree 60, and each half Degree 30 Miles, *&c.* you have the Meridional Difference of Latitude between the two Places, and ſo may find what is required, and anſwer your Queſtion *Inſtrumentally*, as well as *Trigonometrically*, if you be careful in the Operation.

Example in Mercator's Sailing, Caſe I.

A Ship in Latitude 50d. 00m. N. ſails N.W. by N. 987 Miles; I demand the Latitude come to, and Difference of Longitude.

According to the former Directions, extend from Radius to Sine Complement of the Courſe, *viz.* 5 on the Sine

Sine Rumbs, or 36d. 15m. on the Sines) the ſame Extent will reach from the Diſtance 987 to Difference of Latitude 820 Miles or Minutes, or 13d. 40m. which added to the Latitude ſailed from, finds the Latitude come to 63d. 40m. then to find the Meridional Difference of Latitude, extend the Compaſſes upon the Meridian Line from 50d. 0m. to 63d. 40m. that Extent applied to the equal Parts, accounting (as before directed) every 10 Degrees for 600, and each Degree for 60 Miles or Minutes, will be found to be 1522, the Meridional Difference of Latitude. Then for Difference of Longitude, proceed according to the Proportion in *Mercator's Sailing Trigonometrical, Caſe* I. *viz.* Extend from Radius to the Tangent of the Courſe, *viz.* 3. on the Tangent Rumbs, or 33d. 45m. on the Tangents, the ſame Extent will reach from the Meridional Difference of Latitude 1522 to the Difference of Longitude 1017, and ſo in others.

In *Caſe* II. where both Latitudes, and Courſe is given, the Diſtance is found, as in *Caſe* II. of *Plane Sailing Inſtrumental*, and the Difference of Longitude as in *Caſe* I. hereof, which is ſo eaſy, that it needs no Example.

CASE III. *One Latitude, Courſe, and Difference of Longitude given, to find the other Latitude and Diſtance.*

A Ship in Latitude 50 North, ſails N.N.W. till her Difference of Longitude be 7 Degrees, or 420 Minutes, I demand as above.

Extend from the Tangent of the Courſe, two Points to Radius, the ſame Extent will reach from 420 the Difference of Longitude, to 1014 the Meridional Difference of Latitude.

Take the Meridional Difference of Latitude 1014 from the Scale of Equal Parts, then with that Extent, and one Foot in Lat. 50 on the Meridian Line, the other will reach to 59d. 40m. the Latitude come to. Then for the Diſtance extend from Sine Complement of the Courſe (6 on the Sine Rumbs, or 67 : 30 on the Sines) to Radius, the

the ſame Extent will reach from the proper Difference of Latitude 580 to 628, the Diſtance required.

SECT. III.

Parallel and Middle Latitude Sailing Inſtrumental.

THE Proportion for ſolving all the reſt of the Caſes both in *Mercator* and *Parallel Sailing*, and alſo in Middle Latitude, may be ſo eaſily deduced from the Proportions laid down in the *Trigonometrical* Part, that I need ſay no more about them; only in the Inſtrumental Operation, where a Tangent is required, the Point of the Compaſs will ſometimes fall beyond the End of the Line; as ſuppoſe the Proportion were, as Tangent 21d. 30m. to Tangent 37d. 20m. ſo Tangent 42d. 40m. to a Tangent required. And here, if you extend from the firſt Term 21d. 30m. to Tangent 37d. 20m. the ſame Extent will reach from 42d. 40m. to beyond the End of the Scale; but to remedy this, extend from Tangent 21d. 30m. to Tangent 37d. 20m. then with that Extent, and one Foot in Tangent 45, extend the other back towards the Left-hand, and where-ever it lights, keep it fixed and cloſe the other to the third Term, *viz.* Tangent 42d. 40m. then with this Extent, and one Foot in Tangent 45, the other will fall upon Tangent 60d. 45m. the Tangent required.

As for *Traverſe Sailing*, it being compounded of ſeveral Queſtions in *Plane Sailing*, I ſhall not need to ſpeak of it in this Place, ſuppoſing that by what is already laid down in this Section of *Inſtrumental Navigation*, the Learner will be able to make Application, as Occaſion requires, without any further Inſtructions.

CHAP.

CHAP. VI.

Navigation New Modell'd;

OR,

The WHOLE ART Performed

BY A

NEW METHOD.

SECT. I.

Rules and Grounds of the Method.

IN order to the right Underſtanding of this new Method of *Trigonometry*, I ſhall proceed according to the uſual Manner, and ſhall, for the Help of Memory, lay down ſome fundamental Rules or Axioms, upon which the whole Operation depends, and by which all the Caſes in *Plane Trigonometry*, both Right and Oblique, may be ſolved, without any Book, Table, or Inſtrument whatſoever. But before I come to the Axioms, I ſhall premiſe, that whenever a Side and an Angle is given, to find another Side, (which is the firſt and moſt uſeful Caſe in Navigation) there muſt firſt be a Number found, which I call the Natural Radius, not only becauſe it is the Original, from whence the Solutions are deduced, but alſo becauſe being found, it produces

duces the ſame Anſwer in Natural Numbers, that the Radius, or Sine of 90, produces in a Sinical Proportion; and this Natural Radius is thus found.

METHOD the Firſt,

Take the Angle whoſe oppoſite Side is either given or ſought, and divide four times the Square of its Complement to 90 Degrees, by 300 added to three times the ſaid Complement, and then the Quotient added to the ſaid Angle is the Natural Radius required; and this Rule is univerſally true in all Angles from 0 to 90.

METHOD the Second.

But becauſe in Angles under 45, the Complements are above 45, and their Squares amount to greater Numbers than the Squares of the Complements of the Angles above 45; therefore to render the Work as eaſy, and the Contrivance as uſeful as poſſible, I ſhall ſhew another Way to find the Natural Radius for all Angles under 45, and the Rule is,

Divide three Times the Square of the Angle (whoſe oppoſite Side is given or ſought) by 1000, the Quotient added to 57 : 3, (that is 57 $\frac{3}{10}$) the Sum is the Natural Radius required.

This being premiſed, the Rules are theſe;

RULE the Firſt. In Right-angled Triangles.

An Angle and a Side given, to find another Side.

The Natural Radius bears always the ſame Proportion to the Hypotenuſe that the Angle (by which the Natural Radius was found) bears to its oppoſite Side.

Therefore if the Angles and Hypotenuſe be given, it is, As Natural Radius to Hypotenuſe, ſo the Angle to its oppoſite Side. But if the Angles and a Leg be given, then it is, As the Angle to its oppoſite Side, ſo Natural Radius to the Hypotenuſe.

RULE

RULE the Second. In Right-angled Triangles.

Two Sides given, to find a Third.

The Hypotenuſe is equal in Power to the two Legs: That is, the Square of the Hypotenuſe is equal to the Square of both Legs added together; of which ſee more in *Plane Sailing Arithmetical.*

RULE the Third. In Right-angled Triangles.

The Hypotenuſe and a Leg given, to find the other Leg.

Multiply the Sum of the Hypotenuſe, and given Leg by their Difference: The Square Root of the Product is the other Leg required.

RULE the Fourth. In Right-angled Triangles.

Three Sides given, to find an Angle.

Add half the longer Leg to the Hypotenueſe: Then As that Sum to 86, ſo the ſhorter Leg to its oppoſite Angle.

RULE the Fifth. In Oblique Triangles.

Three Sides given, to find where the Perpendicular muſt fall.

Multiply the Sum of the two ſhorteſt Sides by their Difference, and divide the Product by the third Side, which is the greateſt, and upon which the Perpendicular is to fall: The Quotient added to the greateſt Side, or ſubtracted from it, ſhall be double the greater or leſſer Segment, on each Side of the Perpendicular.

Another Way.

Add the Squares of the biggeſt and leaſt Sides together, and from their Sum ſubtract the Square of the middle-

middlemoſt; Half the Remainder, divide by the biggeſt Side, the Quotient is the leſſer Segment, which ſubtracted from the whole Baſe, leaves the bigger Segment.

See another Way in *Axiom* IV. *of Plane Trigonometry.*

SECT. II.

Plane Sailing by a New Method.

I Shall now proceed to ſome Examples in Right-angled Triangles, applied to *Plane Sailing*; and here Note, That to avoid Fractions, I ſhall propoſe the given Angle always in whole Degrees, that being ſufficiently exact in all Uſes in Navigation; nay, a far more exact Way than reckoning by Points, Half Points, or Quarter Points; one Degree being a much ſmaller Part of a great Circle than a Quarter Point of the Compaſs. And I ſhall make uſe of Degrees rather than Quarter Points, not only for its Exactneſs, but alſo becauſe it is a Method much in Uſe aboard of the Men of War, to reckon the Courſe in Degrees, and not in Points and Quarter Points.

CASE I. *Courſe and Diſtance given, to find the Difference of Latitude and Departure.*

Note; I ſhall in every Caſe hereof propoſe the ſame Queſtions that are inſerted in the ſecond Example of each Caſe of *Plane Sailing Trigonometrical.*

A Ship ſails South 25 Degrees, Eaſterly 96 Miles; I demand as above.

The Operation at large.

Note; Where both Legs are required, chuſe always to find the leſſer firſt, becauſe the Natural Radius is more eaſily found, and then find the longer Leg by *Rule the Third*.

For the Departure.

The Angle	25
Multiplied by itſelf	25
	125
	50
Square of the Angle	625
Multiplied by	3
The Product	1875
1875 divided by 1000 is	1.875
To which add	57.3
Sum is Natural Rad.	59.175
Or rather briefer	59.2

Which is exact enough.

The Rule I.

As Natural Radius 59.2. to the Diſtance 96: So the leſſer Angle 25, to its oppoſite Side the Departure.

96	596)24000(40½	
25	320	
480	320	
192		Neareſt which 40½
2400		is the Departure required.

Then for the Difference of Latitude by Rule III.

Hypotenuſe or Diſtance	96.0	
The Dep. in Decimals	40.5	
Their Sum	136.5	
Their Difference	55.5	
	6825	
	6825	
	6825	
The Product	7575.75	

7575(87 The Diff. of Latit.
64

167)1175
1169
(6)

The Departure is 40 ½ (or in Decimals 40.5.) The Difference of Latitude 87.

CASE

CASE II. *Courſe and Difference of Latitude given, to find the reſt.*

A Ship ſails North 38 Degrees Weſt, her Difference of Latitude 120; her Diſtance and Departure is required.

Here the Side oppoſite to the bigger Angle is given, therefore we muſt make Uſe of *Method* I. to find Natural Radius, becauſe *Method* II. ſerves only to Degrees under 45.

38	38	414)5776(13$\frac{124}{414}$
38	3	1636
304	114	394
114	300	
1444	414	
4		
5776		

Becauſe the Fraction is ſo great, I ſhall call the Quotient 14, which added the biggeſt Angle 52, the Sum 66 is the Natural Radius.

Then by Rule I.

As 52 the greater Angle, to 120 its oppoſite Side: So is Natural Radius 66, to the Diſtance required.

Then for the Departure, by Rule III.

120	Diſtance — 152		8704(93 Departure
66	Diff. of Lat. 120		81
720	Sum——— 272		
720	Difference— 32		183)604
7920		544	549
		816	(55)
52)7920(152	Product — 8704		
272			
120			
16			

The Diſtance 152. The Departure 93.

CASE III. *Courſe and Departure given, to find Diſtance, and Difference of Latitude.*

A Ship ſails North 19 Degrees Eaſterly, her Departure 72 Miles; I demand as above.

Here the ſhorter Leg is given; therefore I ſhall find the Natural Radius by *Method* II.

Three times the Square of the given Angle is 1083, this divided by 1000, which is done by cuttiug off three Figures to the Right-hand, the Quotient is 1.083; which becauſe the ſecond Figure in the Fraction is above 5, I add one to the firſt Figure, which is a Cypher, and then call the Quotient 1.1, which added to 57.3, the Sum 58.4, is the Natural Radius required.

19	
19	
171	
19	
361	
.3	
1.083	

Then for the Diſtance, by Rule I.

As the Angle 19, to its oppoſite Side 72: So Natural Radius 58.4, to the Diſtance.

58.4	19)4204(221	The Diſtance
72	·40	required.
1168	·24	
4088	5	
4204.8		

Then find the Difference of Latitude, by Rule III.

Diſtance	221
Departure	72
Sum	293
Difference	149
	2637
	1172
	293
	43657

43657(209
4
40)03657
409) 3264
(393)

The Root 208, but the Fraction being ſo large, I rather call it 209, the Difference of Lat. required.

CASE

CASE IV. *Diſtance and Difference of Latitude given, to find the Courſe and Departure.*

A Ship ſails between the North and Eaſt 117 Miles, her Difference of Latitude 102 Miles; I demand her Courſe and Departure.

For the Departure, by Rule III.

Diſtance — —	117	3080(55
Diff. of Lat. — —	103	25
Sum — —	220	105)580
Difference — —	14	525
	880	(55)
	220	
Product — —	3080	The Departure 55.

Then for the Courſe, by Rule IV.

Hypotenuſe or Diſtance 117
Half the longeſt Leg——51.5

Sum — — — 168.5

As 168.5, to 86: So ſhorteſt Leg, or Departure, 55.5, to its oppoſite Angle, the Courſe.

55.5	168.5)4773.0(22	The Courſe 28 $\frac{110}{117}$ Degrees, which is almoſt $\frac{5}{6}$, *viz.* 28 Degrees, 19 Minutes.
8.6	1403.0	
333.0	559	
4440		
47730		

CASE V. *Diſtance and Departure given, to find the reſt.*

A Ship ſails in the South Weſt Quarter, 124 Miles, her Departure 95 Miles, I demand her Courſe and Difference of Latitude.

For the Difference of Latitude, by Rule III.

Diſtance	124	
Departure	95	6351(79
Sum	219	49
Difference	29	149)1451
	1971	1341
	438	110
Product	6351	

The Square Root of 6351 is 79 or 80 (becauſe the Remainder 110 is more than the Root) the Difference of Latitude required.

Then for the Courſe, by Rule IV.

Hypotenuſe or Diſtance	124	124
Longeſt Leg, which here is Dep. 95 its half		47.5
	Sum	171.5

As 171.5, to 86 : So the ſhorteſt Leg) which here is the Difference of Latitude) 80, to its oppoſite Angle, the Complement of the Courſe.

86	171.5)6880.0(40 Degrees	
80	0200	
6880	20.0	

The Complement of the Courſe is 40 Degrees, and conſequently the Courſe is 50 Degrees, from the South Weſterly, and the Difference of Latitude is 80 Miles *ſers.*

CASE

CASE VI. *Difference of Latitude and Departure given, to find the Course and Distance.*

A Ship sails in the North West Quarter, till her Difference of Latitude be 220 Miles, and her Departure 108; I demand the rest.

For the Distance, by Rule II.

220	108	Square of Diff. Lat. ———	48400
220	108	Square of Departure ———	11664
440	864		
44	1080	Sum of the Squares ——	60064(245
48400	11664		4

Then for the Course, by Rule IV.

As 355, to 86 : So 108 to the Angle of the Course.

108	355)9288(26	The Distance is 245, and the Course 26 $\frac{1}{3}\frac{1}{5}\frac{5}{5}$ Degrees, or 26d. 9m. or N.N.W. somewhat more than $\frac{1}{4}$ West.
86	2188	
684	..58	
864		
9288		

SECT. III.

Oblique Triangles, by a New Method.

How to ſolve all the Caſes in Oblique Plane Triangles, by this New Method, without any Canon, Book, Inſtrument &c.

IN the Solution of *Oblique Triangles*, by this New Method, it is neceſſary that they be firſt divided into two right-angled Triangles, by a Perpendicular let fall, in which obſerve:

Let it fall from the End of a given Side, and oppoſite to the given Angle.

By this Means, the Perpendicular will ſometimes fall within, and ſometimes without; when it falls within, it falls upon ſome intermediate Part of the Baſe, or longeſt Side; but when it falls without, it falls upon one of the ſhorteſt Sides continued; in either Caſe, there is two right-angled Triangles produced, and then the Angles or Sides ſought are found as if they were Parts of a right-angled Triangle.

CASE I.

Given { *The Angle at* A 30.0 / *The Angle at* B 45.0 / *The Side* BC 290 } *Required the Side* AC.

Here the Perpendicular falls from the End of the given Side BC, and oppoſite to the given Angle at B; then in the Triangle B D C is given the Angle at B, and the Side B C, to find the Side CD, which being found, there is given in the Triangle A D C, the Angle at A, and the Side D C, to find A C, the Side required. *Fig.* 48.

I ſhall not trouble the Book with the Operation for finding Natural Radius, it having been often enough repeated

peated in the former Part; but being found by *Method* I. the Natural Radius for the Angle 45 is 63.62; therefore, As 63,62, to Side CB, 290; ſo 45, the Angle at B, to Side oppoſite C D.

45	63.62(13050.00(205	The Side CD 205.
290	··326.00	
4050	··790	
900		
13050		

Now in the Triangle A D C, is given the Angle at A 30d. om. and the Side D C 205, to find A C.

The Natural Radius found by *Method* II. for the Angle 30 is 60. Therefore,

As the Angle at A 30, to Side oppoſite D C 205: So 60 to the Hypotenuſe A C required.

205	30)12300(410.	The Side A C required.
60	.3.	
12300	.00	
	··	

CASE II.

Given { The Side A B 560 / The Side A C 410 / The Angle B 45.0 } Required the Angle at C.

Here the Perpendicular falls without, upon the Side BC continued, and in the Triangle BDA there is given the Angle at B 45, and the Hypotenuſe AB 560, to find AD, which being found you have given in the Triangle C A D, the Hypotenuſe CA, and the Leg A D to find the Leg C D, and the Angle DAC; and by Subtraction, the Angle DCA, and the Angle BCA, in their proper Caſe of right-angled Triangles. *Fig.* 49.

The Operation.

The Natural Radius for the given Angle 45, is 63.62, as found by *Method* I: Therefore, as 63.62 to the Hypotenuese 560; so the Angle at B 45, to Side oppoſite AD.

560
45
2800
2240
25200

63.62)25200.00(396 the Side A D.
6114.0
388.20
..6.48

Then you have A D 396, and A C 410, to find C D by *Rule* III. thus:

Side A C	410	. . .
Side A D	396	11284(106, the Leg CD
		1
Sum	806	
Difference	14	20)012
		00
	3224	
	806	206)1284
		1236
Product	11284	
		(48)

Then for the Angle CAD, by *Rule* IV.

Hypotenuſe A C — 410
Half the Leg A D — 198
Sum — 608

As 608 to 86, ſo 106 to the Angle CAD.

106
86
636
848
9116

608)9116(14$\frac{404}{608}$
3036
604

The Angle CA is 14$\frac{404}{608}$, or rather 15 deg. which ſubtracted from 90, leaves ACD 75 deg. and that ſubtracted from 180, leaves 105 deg. the Angle ACB req. CASE

CASE III. *Given as in Caſe* II. *to find the third Side* BC.

In the whole Triangle BDA, you have given the Angle ABD 45, and the Hypotenuſe BA 560; alſo by Conſequence, the Angle BAD, which is alſo 45, to find the whole Side BD; but in this Caſe the acute Angle being equal, *viz.* 45 Degrees, the Leg BD is equal to AD 396; then having found CD 106, by the ſecond Operation in *Caſe* II. ſubtract it from the whole Side BD 396, the Remainder 290, is the Side BC required.

CASE. IV.

Given { The Side AC —— 410 / The Side AB —— 560 / The Angle at A — 30.0 } Required the Angle at B

In the Triangle AEC, is given the Angle at A 30, and the Hypotenuſe AC 410, to find CE, which by the firſt Caſe hereof is to be found to be 205, and *Fig.* 50. therefore I need not repeat the Operation. Then in the ſame Triangle A C E, there is given the Sides A C 410, and CE 205, to find the Side AE, by *Rule* III.

AC ——	—— 410	. . .
CE ——	—— 205	126075(355, the Leg AE
		9
Sum ——	—— 615	
Difference ——	—— 205	65)360
		325
	3075	
	12300	705)3575
		3525
Product ——	— 126075	
		50

The Leg A E 355 ſubtracted from the whole Side A B 560, reſt E B 205; then in the Triangle B E C, you have given B E 205, and E C 205, to find C B by *Rule*

Rule II. and the Angle B by *Rule* IV. but in this Caſe, BC and EB being equal, the Angle at B is proved 45 Degrees, without Calculation.

CASE V.

Given as in Caſe IV. *to find the third Side* BC.

Although this is the fifth *Caſe* in the *Trigonometrical* Operation, yet the Side BC is neceſſarily found in *Caſe* IV. before the Angle at B can be found; and, therefore, although the Operation in *Caſe* IV. be ſomewhat tedious, yet both the Fourth and Fifth *Caſes* are included in it.

CASE VI.

Given { AB —— 560, AC —— 610, BC —— 290 } Required the Angle at A.

Find AE by the Rule laid down in *Axiom* IV. of *Plane Triangles*. As the Baſe AB 560, to the Sum of the other two Sides, 700: So the Difference of the ſaid Sides 120, to the Difference of the Segments of the Baſe AD 150, as by the Operation below.

Fig. 51.

120	56.0)8400.0(150	To the half Diff. 75 add
700	280	the half Baſe 280, the Sum
84000	000	355 is the greater Baſe AE; but ſubtracted the Difference is the leſſer Baſe EB 205.

Then in the Triangle AEC, there is given AC 610, and AE 355, to find CE by *Rule* III. and the Angle at A by *Rule* IV.

The

The Side AC ——— 410	. . .
The Side AE ——— 355	42075(205
Their Sum ——— 765	405)02075
Their Difference — 55	2025
3825	50
3825	The Square Root of 42075, *viz.* 205, is the Side C E required.
Product ——— 42075	

Then, by Rule IV. find the Angles at A.

Hypotenuſe ———	410
Half the longeſt Leg —	177.5
Their Sum ———	587.5

As 587.5, to 86 : So CE 205, to the Angle oppoſite at A 30.

205	578.5)17630.2(30	The Angle at A.
86	5	required.
1230	50	
1640		
17630		

Although this Method be not altogether ſo expeditious for Oblique Triangles, as the Calculation by Logarithms, becauſe you are obliged to divide every Oblique Triangle into two Right-angled ones, which ſometimes requires two Operations; yet I thought fit to inſert it to make the Method compleat, it being of great Uſe when Tables are wanting, and of ſufficient Exactneſs for moſt Uſes in Navigation: but the Right-angled Caſes, as performed hereby, I ſhall recommend to the Reader, as a Thing very uſeful, ſufficiently exact, and as expeditious as any Method commonly in Uſe.

SECT.

SECT. IV.

How to find the Difference of Longitude, and keep a Reckoning both in Latitude and Longitude, by this New Method of Trigonometry, (as applied to Navigation) without the Help of any Tables or Inſtruments whatſoever, according to Middle Latitude, which is of ſufficient Exactneſs for the Working ſo ſhort a Diſtance as a Day's Run, and conſequently of great Uſe in Navigation.

YOU may remember, that in *Middle Latitude Sailing Trigonometrical*, there is a Proportion for finding the Difference of Longitude, which is, as Sine Complement of Middle Latitude, is to the Departure; So is Radius, to the Difference of Longitude. And therefore, in *Middle Latitude Sailing Geometrical*, one Way which I have propoſed for projecting *Middle Latitude Sailing*, is, by conſtituting a right angled plane Triangle, whoſe Angle at the Baſe is equal to the Complement of Middle Latitude, and the Perpendicular is equal to the Departure: And then by that known Proportion of oppoſite Sides, oppoſite Angles, it will neceſſarily follow that the Hypotenuſe muſt needs repreſent the Difference of Longitude; which being granted, there is no more to do for finding the Difference of Longitude, but only the Solution of the ſaid Right-angled Triangle: Of the ſeveral Varieties of which you have had ſufficient Inſtances in the ſix Caſes of *Plane Sailing* before going, where any two Parts being given, the other two are eaſily found. Nevertheleſs, that nothing may be wanting for the Reader's Inſtruction, I ſhall inſtance in one Queſtion for Example's Sake, which I ſhall firſt work by this new Method, and then by

by the Method propoſed in *Middle Latitude Sailing Trigonometrical*; and laſtly, ſhall work the ſame by *Mercator*, to let the Reader ſee the Sufficiency and Exactneſs of this new and uſeful Invention.

Queſtion. A Ship in Latitude 58d. oom. North, ſails South 25 Degrees Eaſterly 96 Miles: I demand the Latitude come to, and alſo her Departure and Difference of Longitude.

The Courſe and Diſtance is the ſame as in the Queſtion in *Caſe* I. of *Plane Sailing*, as performed by this New Method, and therefore I ſhall refer you to the Operation there, for finding the Difference of Latitude and Departure. The Difference of Latitude being there found to be 87, and the Departure 40½ or 40.5. and therefore (the Courſe being Southerly) the Latitude come to is 56d. 33m. and conſequently the Middle Latitude, found by the Direction and Caution laid down in *Caſe* I. of *Middle Latitude Sailing Trigonometrical* is 57d. 17m. and the Complement of Middle Latitude is 32d. 43m. From hence by the foregoing Directions, is conſtituted the *Fig.* 52. Triangle ABC, wherein the Angle at A is equal to the Complement of Middle Latitude 32d. 43m. and the Side oppoſite BC, is equal to the Departure 40.5, both which are given to find the Hypotenuſe AC, equal to the Difference of Longitude required; and here the Side oppoſite to leſſer Angle being given, I ſhall find Natural Radius by *Method* II. And here obſerve, that although in Queſtions of *Plane Sailing*, you need not regard Minutes in the Angle of the Courſe, becauſe whole Degrees are exact enough to keep Account of a Ship's Way; yet in this Caſe you muſt not omit the odd Minutes in the Angle; and therefore reduce the odd Minutes to Tenths of a Degree, accounting 6 Minutes for one Tenth of a Degree, and 12 for two Tenths, *&c.* And then 42 Minutes is 7 Tenths; and this Angle being 32d. 43m. I ſhall call it 32.7, *viz.* 32 and 7 Tenths, it being but one Minute more, which cannot cauſe any great Error in the Operation.

For

For finding Natural Radius, by Method II.

The Angle — — —	32.7
Mult. by itſelf —	32.7
	2289
	654
	981
Sq. of the Angle —	1069.29
Mult. by — —	3
The Product —	3207.87

Divided by 1000, the Product is 3.207, but it is exact enough to call it 3.2, which added to 57.3 the Sum is 60.6, the Natural Radius required.

Then becauſe the Hypotenuſe is required, the Proportion is,

As the Angle 32.7 is to its oppoſite Side 40.5: So is Natural Radius 60.5, to the Hypotenuſe.

60.5	327)24502(74 $\frac{324}{327}$	
40.5	1612	
30.25	304	
2420.0		
2450.25		

The Product of the Multiplication is but 2450, the other two Figures being but a Decimal Fraction, are to be cut off; but becauſe the Diviſor 32.7 is a Decimal, I add one Figure to the Dividend, as you ſee in the Operation above.

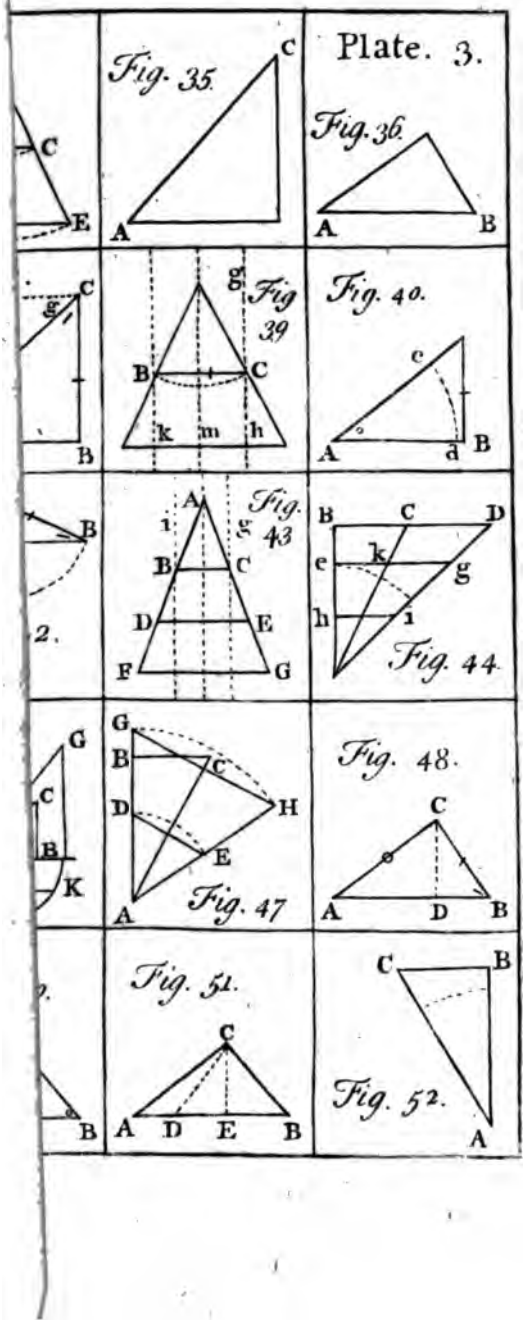
The Difference of Longitude is $74\frac{324}{327}$, which without exactly regarding the Fraction, may be ſet down 75: And this Operation may be performed with great Eaſe and Readineſs, with a little Practice, although I have here ſet it down in Words at large, to make it more intelligible.

The ſame Queſtion anſwered by Middle Latitude Sailing Trigonometrical.

FIND Difference of Latitude and Departure, and conſequently the Latitude come to, with Middle Latitude and Complement of Middle Latitude, as in Caſe I. of *Middle Latitude Sailing Trigonometrical*, which will be found to be as above expreſſed.

Then

Plate. 3.


C
E
Fig. 35.
C
A
Fig. 36.
A
B
C
g
B
g
Fig 39
B
C
k
m
h
Fig. 40.
c
A
d
B
B
2.
A
Fig.
1
g 43
B
C
D
E
F
G
B
C
D
e
k
g
h
i
Fig. 44.
G
C
B
K
G
B
C
D
H
E
A
Fig. 47
Fig. 48.
C
A
D
B
2.
B
Fig. 51.
C
A
D
E
B
C
B
Fig. 52.
A

Then for the Difference of Longitude.

	d.	m.	
As Sine Comp. Mid. Lat. —	32	43	— 9.73278
Is to the Departure —	40.5		— 1.60745
So is the Radius — —	90	00	— 10.00000
To the Difference of Longitude —	74.9		— 1.87467

The foregoing Queſtion anſwered by Mercator's Sailing.

FIND Difference of Latitude, and conſequently the Latitude come to, as in *Mercator's Sailing Trigonometrical*, and you will find the Latitude come to is 56d. 33m. and the Difference 40 ½ or 40.5.

Latitude ſailed from—58d. 00m.	{ Merid. Parts.	4294
Latitude come to — 56 33	{	4133
Meridional Difference of Latitude — — —		161

	Then,	*Co. Ar.*
As proper Difference of Latitude	87	— 8.06048
To Merid. Diff. of Latitude —	161	— 2.20682
So is the Departure — —	40.5	— 1.60745
To the Difference of Longitude —	74.9	— 1.87475

And thus you ſee the exact Agreement of this with the true Operation, as performed by *Mercator's Sailing*; it not differing from it ſo much as one Quarter of a Minute in Longitude, in ſo great a Diſtance as 123 Miles, and in a Latitude ſo near the Pole as 58 Degrees, where there is much more Danger of contracting an Error than in leſſer Latitudes, or Voyages nearer the Equinoctial.

CHAP.

CHAP. VII.

Practical Navigation,

OR,

The Application of the foregoing Rules to the actual keeping of a Reckoning, according to the ſeveral Kinds of Navigation.

THERE are four Things very neceſſary to be known by all that take upon them the Charge of conducting a Ship from one Part of the World to another, which may properly be called the Practical Part of Navigation.

The firſt is a right Underſtanding of the Compaſs, with the Variation thereof, in order to the true Knowledge of the Courſe made good.

The ſecond is the Log-line and Half-minute Glaſs, that the Knots on the Log-line be a due Length, and that the Glaſs be juſt a Half-minute, that thereby you may as near as poſſible find the true Diſtance.

The third is the right Manner of taking and working an Obſervation by the Sun by Day, or by the Stars by Night, thereby to find the true Latitude, and to correct the Dead Reckoning, if there have been an Error contracted either in the Courſe or Diſtance.

And, fourthly, having by theſe Means and Helps finiſhed your Reckoning, and being come near the deſired Port, it is alſo neceſſary, that there be a right Underſtanding of the Tides, which Way the Ebbs and Floods ſet, and what Moon makes full Sea upon any Coaſt, that ſo it may be known how long to ride at Anchor,

Anchor, or lie by to wait the Tide, if you know you are too ſoon; or what ſail to make to ſave your Tide, if you fear being too late: And theſe four Things I ſhall handle in this Part, and that in ſuch a Manner, as may be intelligible to the meaneſt Capacity, and moſt uſeful as well as moſt eaſy to be put in Practice at Sea.

SECTION I.

Of the Variation of the Compaſs.

THE Way commonly taught for finding the Variation of the Compaſs, is by the Sun's Azimuth, or Amplitude; but theſe Ways not being attainable by any but them that have learnt ſomething of Aſtronomy; and being alſo treated of in other Books, I ſhall not trouble the Learner with them, but proceed to a far eaſier Way, which is this:

When you are at Sea, and deſire to know the Variation of the Compaſs, take your Quadrant about 8, 9, or 10 a Clock, when you ſuppoſe the Sun is near about half up from the Horizon to the Meridian, and take an Obſervation of the Sun's Altitude, as you would do at Noon to find the Latitude of the Place, which being done, lay by your Quadrant (letting the Vanes remain unremoved) and by your Azimuth Compaſs (if you have one on board) ſet the Sun, and mind what Point of the Compaſs the Sun is upon at that Obſervation. This done, wait till the Afternoon, that the Sun grows almoſt as low as he was when you obſerved in the Forenoon, and then with your Vanes fix'd, as in the firſt Obſervation, obſerve till the Sun be ſo low, as that the Vanes ſo fixed will juſt take the Sun's Altitude without altering them; which done, obſerve immediately (as before) upon what Point of the Compaſs the Sun is at

that Obſervation: Then the Space between that Point which the Sun was upon at the firſt Obſervation, and that Point upon which the Sun was at the laſt Obſervation, divided into two equal Parts, the Middle is the true South Point of the Compaſs, and the Diſtance between that and the South Point of the Card, is the Variation required.

Example.

Suppoſe at the Forenoon Obſervation, I find the Sun by the Compaſs to be South Eaſt (it matters not what his Altitude be, ſo you mind what it be, or elſe let the Vanes ſtand unremoved, till the Afternoon) and ſuppoſe in the Afternoon I find, when the Sun hath the ſame Altitude, that he bears Weſt South Weſt; now the Diſtance between South Eaſt and Weſt South Weſt is ten Points, the Half of that is five Points, which reckononed from South Eaſt towards the Weſt South Weſt, it falls upon the South and by Weſt; therefore I conclude that the South and by Weſt Point of the Compaſs points to the true South Point, and the Diſtance between the South and by Weſt Point (which is the true South) and the South Point of the Compaſs (which we may call falſe South) or (magnetical South) is the Variation of the Compaſs; and becauſe the magnetical South is Eaſtwards from the true South; therefore the magnetical North is Weſtward from the true North. Here I conclude, that the Variation is one Point Weſterly, *&c.*

In this Caſe there is only this Caution to be obſerved, *viz.* that this Obſervation be not made when the Ship is running very faſt Northwards or Southwards, which may make ſome ſmall Error, though ſcarce diſcernable; for if the Ship ſtood ſtill, the Sun would have exactly the ſame Altitude at 8, 9, or 10, in the Forenoon, that it would have at 2, 3, 4, in the Afternoon; but if the Ship ſails very faſt to the Southward in North Latitude, or to the Northward in South Latitude, ſhe raiſeth the Sun a little, and by Conſequence the Sun will be ſomewhat higher at 4 in the Afternoon than at 8 in the Morning,

ing, and may cauſe ſome Error, but it is little, and a Thing that ſeldom happens: And if it do happen that your Courſe be North or South, and the Wind ſo fair, you may refer your Obſervation till another Day, (it being not neceſſary to ſet the Variation every Day) and thereby the Error may be avoided, and yet the Variation exactly found as often as is neceſſary.

Note; I ſhall ſhew how to find the Variation by the Sun's Azimuth and Amplitude hereafter in the Aſtronomical Part.

SECT. II.

How to divide the Log-line, and try a Half-Minute-Glaſs.

THEY that take upon them to be Maſter, Mate, or Pilot of a Ship, and would be very exact and accurate in the keeping a Reckoning or Account of the Ship's Way, ought to take Care before they go from the Shore, to be furniſhed with all Things neceſſary for that Purpoſe. For the beſt of Scholars, the greateſt Artiſts, the moſt profound Mathematicians, or the moſt experienced Navigators, may be deceived, and carried into the groſs Errors, by a Defect in their Inſtruments, or Means for keeping a Reckoning, as well as the moſt ignorant may be by a Defect in their Knowledge; and ſo far as they deſign that their Account ſhall not depend upon their Dead Reckoning, they ought chiefly to be careful in theſe two Things.

Firſt, the Half-Minute-Glaſs, that it be of a due Length; but if it be longer than it ſhould be, it makes the Ship by Eſtimation to run ſo much more than indeed ſhe does, and by that Means perhaps, in a Month or 6 Weeks Sailing, you will expect to arrive at your Port, or make ſuch or ſuch Land, when indeed you are 50, 60, or 80 Leagues, or more or leſs ſhort of it, according as the Error of your Glaſs is more or leſs. And altho' it is hard to know a true Half-Minute-Glaſs,

yet there are theſe two Ways to prove them, and know whether they are right or wrong.

The firſt Way is by an Expedient mentioned by Mr. *Henry Philips*, in his *Advancement of the Art of Navigation*, and alſo quoted by *Seller*, in his *Practical Navigation*, and 'tis this: Take a Bullet of any competent Weight, it matters not, and make faſt to it a Piece of fine Thread, or Silk, of the juſt Length of 38 ½ Inches; let there be a Nooſe on the End of the Thread, and let the very End of the Nooſe be juſt 38 ½ Inches from the Center of the Bullet, (as I ſaid before) then hang it up by the Nooſe upon a ſmall Pin, where it may hang at Liberty, and ſwing freely, and ſo give it Way, and each Swing ſhall be a true Second of Time; that is, each Time that it paſſes by the Perpendicular let fall from the Pin on which it hangs, ſhall be a Second; and every Time of its Return to the Place where it firſt begun its Motion, is two Seconds of Time, and a Glaſs that runs till the ſaid Bullet hath made 30 Swings ſhall be a true Half-Minute-Glaſs.

A ſecond Way (if it may properly be ſo called) is by the Experience of thoſe that have had Occaſion to uſe a Glaſs in long Voyages; and having a Line rightly divided, by a Glaſs of ſo true a Length, that their Dead-Reckoning, when carefully kept, hath agreed with the Truth of their Obſervations; and that their making of Land, *&c.* hath fallen out according to Expectation, by the Dead-Reckoning; I ſay ſuch a Glaſs, or another of the ſame Length, ought to be preferred before any other, as a true Half-Minute-Glaſs.

A ſecond Thing neceſſary, in order to the Keeping of a true Reckoning, is to take Care that the Log-line be rightly divided; for although the Glaſs be true, yet if the Log-line be divided into Knots too long or too ſhort, it muſt needs make an Error in the Reckoning, according to the Proportion of the Error in Diviſions of the Line, if you work by a true Half-Minute-Glaſs. Indeed, if the Diviſions of the Log-line be too ſhort, and the Glaſs alſo too ſhort, (or if both be too long, which is the ſame) then the one Error helps to compenſate the other; but if the Faults in the Line and in the Glaſs

Glaſs be contrary, that is, the one too long, and the other too ſhort, the Fault is intolerable.

As for the Length of each Knot on the Log-line, or how it ſhould be divided, there are different Opinions amongſt different Authors and Navigators. Indeed it is an undeniable Truth, and apparent to all Men's Reaſon, that one Knot upon the Log-line ſhould be the 120th Part of a Mile; becauſe half a Minute is the 120th Part of an Hour; (for as the Whole to the Whole, ſo a Part to the Part, *&c.*) but the Difficulty ariſes from the different Opinions, as to how many Feet, Yards, *&c.* there is in one Degree of a great Circle upon the Earth. Mr. *Oughtred*, in his Circles of Proportion, will have 66 $\frac{1}{4}$ Miles to anſwer one Degree upon the Earth, each Mile containing 5280 Feet. Hence there is by his Account, 349800 Feet in one Degree of a great Circle upon the Earth, and 5830 Feet in one Minute, or 60th Part of ſuch a Degree, and conſequently the 120th Part of a Minute, or Length of one Knot upon the Log-line, muſt be 48 $\frac{7}{12}$ Feet.

But Mr. *Norwood*, in his *Seaman's Practice*, *P.* 43. (relating an Experiment of his for finding the Quantity of one Degree of a great Circle upon the Earth) ſaith, that one Degree contains 367200 of our *Engliſh* Feet to a Degree, which Account, without any Allowance would give 51 Feet to one Knot of the Log-line, although, for Reaſons there mentioned, he allows 1 Foot out of the 51, and ſo would have one Knot of the Log-line to be juſt 50 Feet: But how far that Experiment of his is to be depended upon, (conſidering the Unevenneſs of the Ground, and Crookedneſs of the Ways and other Inconveniencies, which he could only give Allowance for according to his Judgment) and alſo how far that one Foot in 51 may compenſate the Way that the Log makes after the Ship, I ſhall not take upon me to determine. In the mean time I ſhall, with Submiſſion to better Judgments, rather adhere to the Way of dividing the Log-line, that is commonly received, and uſed by moſt Mariners, I mean that of 42 Feet, or 7 Fathom to one Knot. Now it will preſently be objected, that according to that Diviſion for Half a Minute, multiplying that

by 120, for 1 Mile, and that Product by 60, for 1 Degree, there is by Conſequence but 302400 Feet in a Degree, which ſeems to contradict, and intolerably to vary from the Opinions of the ingenious Mr. *Norwood*, and other experienced Men in that Kind.

I anſwer, it doth not contradict them, at leaſt ſo much as at firſt Appearance it ſeems to do; for one grand Reaſon why I agree to theſe ſhorter Diviſions is, to give Allowance for the Way that the Log makes after the Ship; for altho' there is ſo much ſtray Line allow'd, as may be ſuppoſed to veer the Log moderately well out of the Eddy of the Ship's Wake, yet it cannot be ſuppoſed, but that ſtill the Log muſt have ſome Way after the Ship, if but by the Weight of the Line, which although but light, yet the Water being but a ſoft fluid Subſtance, the Log muſt needs have a Motion after the Ship, and eſpecially ſailing large, and in a freſh Gale, it cannot be but that the Wind will have ſo much Effect upon the Log, and ſo much of the ſuperficail Part of the Water, as to ſhove it along after the Ship; and that, in my Opinion, much more than one Foot in 51.

Indeed another Conſideration, which may be accounted a ſecond Reaſon why I do adhere to that Way of dividing the Line, is, becauſe if there is an Error, it is on the ſafer Side; for although the Truth is beſt, if it could be attain'd, yet if an Error muſt be, 'tis better that the Reckoning be a-head of the Ship, than that the Ship ſhould be a-head of the Reckoning; and better to look out for Land before we come at it, than to be aſhore before we expect it.

But my third Reaſon is, the Confirmation of this my Opinion, by the daily Practice and Experience of many, if not mo Mariners, who uſe this Way, and find the Succeſs to anſwer their Expectations, at leaſt much nearer than a much larger Diviſion would do. 'Tis true, if the Generality of Glaſſes be ſo much too ſhort, as to countervail thoſe too ſhort Diviſions (if they are too ſhort) it were to be wiſh'd that the Errors in one were rectified, and then the Faults in the other might be amended; but till then I ſhall recommend that Way of following 42 Feet, or 7 Fathom, to one

one Knot of the Log-line. Indeed if it be, as it is reported by ſome, that to make Amends for the Shortneſs of the Knots, the Glaſſes are commonly made but 27 Seconds; and if ſo, then if the Glaſſes were regulated and increaſed from 27 Seconds to 30, the Knots, by the ſame Proportion, ſhould be alſo increaſed from 42 Feet to 46 ⅓ Feet to one Knot, which ſeems more agreeable to Reaſon, and to Mr. *Norwood*'s Obſervation.

Note; When you divide the Log-line you muſt allow 12, 15, or 18 Fathom of Stray-line, according to the Bigneſs of your Ship, accounted from the Log, before you begin to ſet out the Knots, and then put in a red or white Rag, and from thence begin to divide the Line into Knots. The Reaſon of the Stray-line is to veer the Log pretty well out of the Ships Wake, leaſt the Eddy ſhould ſuck the Log after the Ship, and deceive you in your Reckoning.

SECT. III.

How to make a Plane Chart.

THE Log-line being thus divided, and the Half-Minute-Glaſs examined and regulated, the next Thing is to make a Chart for the Voyage intended; and of Charts there are ſeveral Sorts.

The firſt is commonly called a Plane Chart, in which the Degrees of Longitude and Latitude are every where equal, without any Reſpect to the Globularneſs of the Earth, but rather ſuppoſing the Earth and Sea to be a plane Superficies; and hence it is, that this Projection is falſe, except in Places under or near the Equinoctial. However it being much in Uſe, I ſhall lay down the Projection of it as followeth.

If you would make a Plane Chart for all the Earth and Sea, 'tis beſt to do it upon two Sheets of Paper;

one Half upon each Sheet. Through the Middle of each Sheet, croſs-ways, from the Right-hand to the Left, draw the ſpotted Line A B, which divided into 180 equal Parts, by any equal Parts of the Scale, as large as your Paper will contain, which you may mark at every 10 Degrees with Figures, 10, 20, 30, *&c.* to 180, beginning at any Place where you intend to reckon your Longitude from, which ſuppoſe let it be in *London*, let your Chart begin at the Weſt or Left-hand, and ſo reckon Eaſtwards, as in the following Example, where the two Charts contain all the 300 Degrees of Longitude in Compaſs, and 90 Degrees of Latitude each Way from the Equinoctial. Then from the Middle of the Chart, as a Center, draw the 32 Points of the Compaſs, as you ſee done. Then for inſerting any known Place in the Chart, find by the Table of Latitude and Longitude of Places what Latitude and Longitude your Place hath, and place it in that Latitude and Longitude in the Chart; as for Example, Suppoſe I would inſert the Land's-End of *England*, and the Weſt-End of *Cyprus* in the *Straits*, and would find their Bearing and Diſtance; according to the Plane Chart, I find the Latitude of the Lands's End of *England* in the Table is 49d. 55m. North, and Longitude 5d. 14m. W. I reckon upon the Line AB, which is the Equinoctial, till I come at 5 Degrees, *viz.* 5 of the ſmall Diviſions, and as near as I can compute, ſomewhat leſs than $\frac{1}{4}$ of another ſmall Diviſion, for the 14 Minutes, and ſetting one Foot of the Compaſſes in that Mark, I extend the other to the next North and South Line, and running them up into Latitude 49d. 55m. I make the Mark ⊙ to repreſent the *Lizard*; and by the ſame Method I find the Weſt-end of *Cyprus* at the Mark △, then the Diſtance between theſe two Marks taken in your Compaſs, and applied to the Equinoctial Line AB, accounting every Degree 60 Miles, and every 10 Degrees 600 Miles, gives the Diſtance between the two Places, according to the Plane Chart; and then for the Courſe, obſerve what Line, or Point of the Compaſs, a Line

Fig. 54.

Fig. 53.

ſuppoſed

ſuppoſed to be drawn between theſe two Places would be parallel to, which in this Caſe you ſee is an E.S.E. and W.N.W. Line, the neareſt Point repreſenting the Courſe required.

In like manner you may inſert any other Place whoſe Latitude and Longitude is given; as for Inſtance, I have inſerted the following Places, which becauſe the Draught is too ſmall to contain the Names at large. I have repreſented them by the following Letters annexed to them.

The *Lizard.*
△ The Iſland of *Cyprus*, in the *Straits.*
a Majorca, an Iſland in the *Straits.*
b Barbadoes.
c Jamaica.
h Cape *Henry*, in *Virginia.*
o Bengal, in the *Eaſt-Indies.*
d Cape *Bona Eſperanza.*
e The *Naze* of *Norway.*

Theſe are ſufficient to let the Learner ſee how to ſet down the Places in a Plane Chart.

But ſuppoſe you are to ſail from any one of theſe Places, or any other Place, to ſome other Port, it is beſt to make a Chart for the particular Voyage, to contain only ſo much of the Earth and Sea as is contained between the two Places, or little more, and then you may make your Degrees of Latitude and Longitude larger, as in the following Example.

A Ship ſets ſail from *Flamborough-Head*, in Lat. 54d. 8m. North, and Longitude 0d. 10m. W. intending for the *Naze* of *Norway*, in Lat. 58d. 00m. and Long. 6d. 2m. E; I deſire a Chart made of that Voyage.

This Chart is made to contain from 54 to 58 of Latitude, and from 16 to 21 of Longitude; and then by the former Rules, the Point A repreſent *Flamborough-Head*, and the Point ⊙ upon the oppoſite Corner, is the *Naze* of *Norway*: Then *Fig.* 54.

at

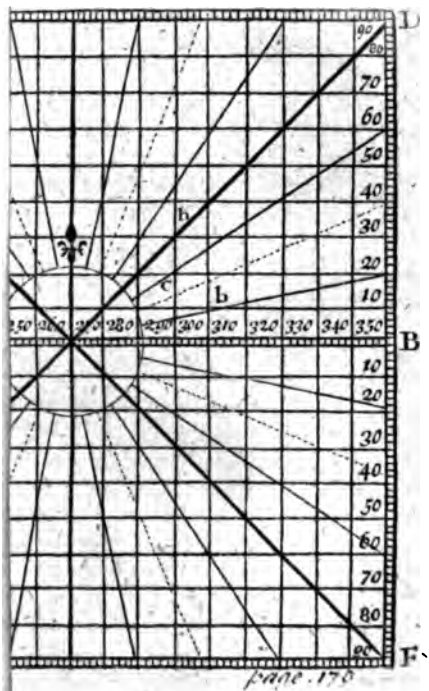
at *Flamborough-Head* the Place ſailed from, as a Center, I deſcribe a Quarter of a Compaſs, which in this Caſe is always ſufficient, and thus is the Chart ready for the Voyage.

As for ſetting off the Courſes and Diſtance, or Difference of Latitude and Departure, upon a Chart, commonly called, pricking a Chart, I ſhall refer it till I come to give ſome Examples of keeping a Journal by the Log and Compaſs.

How to make a Mercator's Chart.

A *Mercator's* Chart appears ſomewhat like a Plane Chart, only with this Difference, that whereas, in a Plane Chart, the Degrees of Latitude and Longitude are every where equal, it is not ſo in a *Mercator's* Chart, for in it the Degrees of Latitude bear the ſame Proportion to the Degrees of Longitude, that they do upon the Globe; and the Invention of this Chart is moſt properly owing to our worthy and ingenious Countryman, Mr. *Edward Wright*, as may be ſeen in his Corrections of the Errors of *Navigation*: However, (I know not well for what Reaſon) unjuſtly aſcribed to *Mercator*. Now, although upon the Globe the Degrees of Latitude are every where equal, and the Degrees of Longitude grows leſs nearer the Poles; yet in this Chart it is not ſo, but the Meridians are Parallels, and every where equal, as in a Plane Chart, but the Degrees of Latitude grow bigger near the Poles; ſo that in a *Mercator's* or *Wright's* Chart, there is always the ſame Proportion between a Degree of Latitude, and a Degree of Longitude, in any Parallel, as there is upon the Globe itſelf, though the Diſtances are extravagantly diſtorted, eſpecially near the Poles.

For the Projection of this Chart, there are two Lines upon *Gunter's* Scale, commonly placed next the Bottom, on that Side upon which the Logarithmical Numbers, Sines, and Tangents are; the loweſt of the two is a Scale of equal Parts, and the next to it is called the Meridian Line, by the Help of which, if you would draw a large Chart of all the World between 85 Deg. of North Latitude, and 85 Degrees of South Latitude, you


D
B
F
90
80
70
60
50
40
30
20
10
250
260
270
280
290
300
310
320
330
340
350
10
20
30
40
50
60
70
80
90
h
c
b
page 170

you muſt prepare large Paper, or paſte Sheets of Paper together, till your Sheet contain about four Feet each Way; through the Middle of which draw the Equinoctial Line, as you ſee in the Plane Chart before inſerted, and graduate it with 10, 20, 30, *&c.* by thoſe Diviſions upon the Line of equal Parts now mentioned, which done, when you ſee how far the 180 Degrees of Longitude reach (if you make the Chart in two Parts, or the 360 Degrees, if you make it all in one Draught, as your Sheet of Paper four Feet ſquare will eaſily contain) and there draw Lines at Right-Angles, with the Equinoctial Line, as you ſee in the foregoing Charts, the Lines CAE, and DBF, *Fig.* 53, then theſe Lines graduated from A the Equinoctial, both Ways, by the Graduations upon the Meridian Line upon the Scale, ſhall ſet off every Parallel of Latitude according to *Mercator*; and when the Lines on both Sides are ſo graduated upwards and downwards, from the Equinoctial, the Lines drawn from every Degree on one Side to the ſame Degree on the other Side, ſhall repreſent the Parallels of Latitude required.

But becauſe theſe Graduations would be too ſmall to make a Chart by, for any particular Voyage, it is better to make the Chart larger, and in that Caſe the Want of a Meridional Line ſo large, may be ſupplied by a Table of Meridional Parts; for having drawn the Equinoctial, or any other Parallel of Latitude, which is the ſame, for one Out-ſide of your Chart; ſet off 60 of any equal Parts for every Degree of Longitude, both at the Top and Bottom of your Chart; this done, find (by the Rules laid down in *Mercator's Sailing Trigonometrical*) the Meridional Difference of Latitude, or the Meridional Parts contained between that Degree and the next, theſe taken from the ſame Scale of equal Parts, and ſet from the laſt Degree marked, ſhall find the next Degree, and ſo in the reſt.

The Rumbs, or Points of the Compaſs, are exactly the ſame as in a Plane Chart.

I ſhall explain what hath been ſaid by an Example of a *Mercator*'s Chart, from *Flamborough-Head* to the *Naze* of *Norway* before-mentioned.

Flam-

	Lat.	Long.
Flamborough-Head	54d. 8m.	0d. 10m. W.
Naze of Norway	58 0	6 2 E.

It is beſt to make the Chart to a whole Degree, and in this Example I ſhall, as before, make it from Lat. 54 to 58, and 9 Degrees of Longitude.

Merid. Parts for Lat. 58d. 0m.	4294
Merid. Parts for Lat. 54d. 8	3878
Merid. Diff. of Lat. in the whole Chart	416
Diff. of Longitude in the whole Chart	540

Having drawn the Line *d a*, ſet off the whole Meridional Difference of Latitude 416, off any convenient Scale of equal Parts, from *d* to *a*, and draw *a b*, and *d c*, perpendicular to *d a*, and ſet off the whole Difference of Longitude 9 Degrees, or 540 M. from *d* to *c*, and *a* to *b*, and draw *c d*; thus you have the whole Subſtance of your Chart.

Then ſet 60 of the ſame Parts from *d* to 0, and from 0 to 1, and from 1 to 2, *&c.* both upon the Line *d c*, and upon the Line *a b*, and draw the Line ⊙ 0——0 1——1, *&c.* thus is your Longitude graduated.

Then for the Latitude, find the Meridional Difference of Latitude, between Lat. 54 and 55, which is 103, therefore ſet 103 of the ſame equal Parts from *a* to 55, and from *b* to 55, and draw the Line 55—55; then find the Meridional Difference of Latitude between Lat. 55, and Lat. 56, which is 106, which ſet from 55 to 56, on both Sides, and draw the Line 56—56, and ſo find alſo the Line 57—57. Then upon the Center A, which repreſents the Place ſailed from, draw a Quarter of a Compaſs, the Rhumb upon that Compaſs ſhews the true Courſe from *Flamborough-Head*, at the Point A, to the *Naze* of *Norway*, at the Point ⊙, which you ſee differs much from the Courſe found by the Plane Chart.

The

The Diſtance between any two Places in a *Mercator's* Chart is thus found; find the Difference of Latitude between the two Places, which here is 3d. 52m. or 232 Minutes, which ſet off upon the Lines *a b*; take the 3 whole Degrees from 17 to 20, and the 52 Min. in the graduated Degree, accounting every Part 10 Min. becauſe the Degree is divided into 6 Parts; then keeping your Compaſſes at that Extent, lay a Ruler ſo, as it may juſt cut the two Places, whoſe Diſtance is required; then ſet one Foot of your Compaſſes at the Ruler's Edge, ſo as that the other turned about may juſt touch ſome Eaſt and Weſt Line, then keeping that Foot faſt that ſtood againſt the Ruler, open the other to the croſſing of the Ruler, and the ſaid Eaſt and Weſt Line, that Extent meaſured on the Parallel *a b*, allowing 60 Miles to every Degree, gives the true Diſtance required. *Fig.* 55.

Thus a Scale laid from *a* to ⊙, deſcribes the pricked Line *a* ⊙, then with 3d. 52m. in your Compaſſes, and one Foot in *b*, the other turned about will juſt touch the Line 57——57; then obſerve where the Line 57——57 cuts the prick'd Line *a* ⊙, as in *k*, the Extent *b k*, meaſured on the Line *a b*, gives the true Diſtance.

How to make a true Plane Chart.

BUT a Third Sort of Charts I ſhall next deſcribe, which is as true as *Mercator's*, and yet as plain, eaſy, and expeditious for Practice, as the Plane Chart, but it cannot be made but by a particular Voyage, and generally when you intend to come back the ſame Way you go, and it is thus made.

Having the Latitude and Longitude of the two Places between which you are to ſail, find the true Courſe and Diſtance, by Caſe the Sixth of *Mercator's Sailing*, which found, ſet off the Courſe and Diſtance between the Place ſailed from, and the Place bound for, as you are taught in *Traverſe Sailing Geometrical*; ſo have you two

two Points repreſenting the two Places, and if your Ship ſail upon ſeveral Courſes and Diſtances, in Form of a Traverſe, as you are taught in *Traverſe Sailing Geometrical*, and ſo you may every Day ſet off the Courſe and Diſtance from the Ship to the Place bound for, according to *Mercator*, and yet it is done as eaſily as in *Plane Sailing*. I ſhall inſtance in the fore-mentioned Voyage.

	Lat.	*Long.*
A Ship ſails from *Flamborough-Head*	54d. 8m.	0d. 10m. W.
Intending for the *Naze* of *Norway*	58 0	6 2 E.

For the Courſe, according to Mercator.

As Merid. Diff. Lat.	416	2.61909
Is to Radius	90d. 00m.	10.00000
So is Diff. of Long.	372	2.57054
To Tangent of the Courſe	41 48	9.95145

Then for the Diſtance.

As Sine Comp. of Courſe	41d. 48m.	9.87243
To proper Diff. of Lat.	232	2.36548
So is Radius	90 00	10.00000
To the Diſtance	392	2.59305

Fig. 56.

Here A repreſents *Flamborough-Head*, B the *Naze* of *Norway*, the Line AB the true Diſtance, 278 Miles, the Angle CAB 33d. 22m. the Courſe from the Meridian, and in this Chart the Degrees of Latitude are equal Diviſions, and eaſily repreſented, but the Degrees of Longitude, if they are inſerted here, would be curbed Lines, and hard to project; nor is it needful, ſeeing upon this Chart you need not regard the Longitude as you go along, but only the Courſe, and Diſtance upon each Courſe, according to the Rules laid down in the ſecond Queſtion of *Traverſe Sailing Geometrical*.

Having thus ſhewed how to make the ſeveral Charts, I ſhall ſhew the Uſe of them, when I come to give ſome Examples of keeping a Journal, in which I ſhall inſtance in

in the ſame Voyage, for which theſe Charts are projected, and ſhall ſhew the Learner how to prick off every Day's Work upon each Chart; of which hereafter.

SECT. VI.

How to take an Obſervation.

THE moſt uſeful and eaſy Way to take an Obſervation by the Sun, is with a Quadrant, commonly called *Davis*'s Quadrant, conſiſting of two Arches, in ſome a 30 Arch, and 60 Arch; but more commonly of late, an Arch of 25 Degrees, and another of 65; but the Way of uſing them is all one and the ſame; for by theſe Quadrants you do not ſo readily find the Sun's Altitude, but the Complement of the Sun's Altitude, commonly (and properly) called the Sun's Zenith Diſtance, being the Sun's Diſtance from the Zenith, or Point right over our Head, which is eaſily found by one of the Quadrants; for having fitted your Vanes ſo, as that when you have the Horizon right through the Sight Vane and Horizon Vane, the Shadow may at the ſame Time fall directly from the Top of the Shadow Vane to the Top of the Slit (which is the Middle) of the Horizon Vane, ſtill removing the Sight Vane downwards, as you obſerve the Sun to riſe, till you find that the Sun is upon the Meridian, and then you have done your Obſervation for that Day. This done, obſerve what Numbe or Figure you have upon the 60 (or 65) Arch, juſt under the upper Edge of the Shadow Vane, (which ſhould always be placed upon an even 10 Degrees, to ſave Trouble in the Edition) and alſo to obſerve what Degree and Minute you have upon the 30 (or 25) Arch, juſt under the Middle of the Sight Vane, even with the Line or Stroke that goes from the Hole along the Middle of the Vane;

and theſe two Numbers added together, the Sum is always the Zenith Diſtance, which is to be uſed as in the following Directions for working an Obſervation.

How to work an Obſervation.

THERE are but four Caſes, or Varieties in working an Obſervation, in whatſoever Part of the World you be, or whether the Sun's Declination be North or South.

The firſt is, when the Sun is between the Horizon and the Equinoctial, and then the Rule is, ſubtract the Declination from the Zenith Diſtance, the Remainder is the Latitude of the Place.

Demonſtration.

Fig. 57. The Latitude of the Place is the Diſtance between the Equinoctial and the Zenith of that Place. The Sun's Declination is the Sun's Diſtance from the Equinoctial: And the Sun's Diſtance from the Zenith of the Place, is the Zenith Diſtance or Complement of the Sun's Altitude. Now if from ⊙ Z the Zenith Diſtance, you ſubtract ⊙ E, the Sun's Declination, there remains EZ, the Latitude of the Place of Obſervation.

Example.

Suppoſe the Sun's Zenith Diſtance be Z ⊙ 76, and the Sun's Declination South E ⊙ 16, ſubtract ⊙ E the Declination 16, from ⊙ Z the Zenith Diſtance 76, there reſts EZ 60, the Latitude required.

The ſecond Variation is, when the Sun is between the Equinoctial and the Zenith, and then the Rule is, Add the Zenith Diſtance to the Sun's Declination, the Sum is the Latitude of the Place: For if to ⊙ Z, the Zenith Diſtance, you add ⊙ E, the Sun's Declination, the Sum is

is E Z, the Diſtance between the Zenith and the Equinoctial, which is the Latitude required.

Example.

Suppoſe the Sun's Zenith Diſtance ☉ Z 35, the Sun's Declination North E ☉ 10, if to ☉ Z 35 the Sun's Zenith Diſtance, you add E ☉ 10 the Sun's Declination, the Sum muſt needs be EZ 45. the Latitude required. *Fig.* 58.

The Third Variety is when the Sun is between the Zenith and the elevated Pole, then the Rule is, ſubtract the Zenith Diſtance from the Declination, the Remainder is the Latitude of the Place.

Example.

Suppoſe the Sun's Declination be E ☉ 20, and the Zenith Diſtance Z ☉ 10; ſubtract the Zenith Diſtance Z ☉ 10, from the Sun's Declination E ☉ 20, there reſts E Z 10, the Latitude required. *Fig.* 59.

The Fourth Variety is when the Sun is between the elevated Pole and the Horizon, and then the Rule is, ſubtract the Sun's Complement of Declination for the Zenith Diſtance the Remainder is the Complement of Latitude.

Example.

Suppoſe the Sun's Declination be 22, (its Complement is 68) the Zenith Diſtance 85, then from Zenith Diſtance ☉ Z 85, ſubtract the Complement of Declination ☉ P 68, the Remainder Z P 17, is the Complement of Latitude, which ſubtracted from 90, leaves 73, the Latitude required. *Fig.* 60.

But becauſe 'tis ſeldom that any ſail ſo far North or South, as that they can conveniently take a backward Obſervation by the Sun, under the elevated Pole, in

this Caſe it may be done by a forward Obſervation, and work with the Sun's Altitude or Heigth above the Horizon, and then the Rule is, Add the Sun's Altitude to the Complement of Declination, the Sum is the Latitude; thus if in the laſt Example, you add the Sun's Altitude, O ⊙ 5, to the Complement of Declination ⊙ P 68, the Sum O P 73, is the Height of the Pole above the Horizon, which is the Latitude of the Place.

This ſame Operation will hold in taking an Obſervation by a Star, when under the elevated Pole, becauſe both here, and in all other Caſes in obſerving by the Stars, we are obliged to take the Obſervation forward, becauſe a Star caſts no Light ſufficient for a backward Obſervation, and then, inſtead of the Zenith Diſtance, work with the Altitude.

In forward Obſervations, whether by Sun or Stars, there are alſo Varieties, as in a backward Obſervation, which I ſhall only ſpeak to, the Demonſtrations being pretty evident from the foregoing Figures.

The firſt Caſe is, when the Star is between the Equinoctial and the Horizon, and then the Rule is, Add the Altitude of the Star to its Declination, the Sum is the Complement of Latitude, which ſubtracted from 90 leaves the Latitude required.

Secondly, When the Star is between the Equinoctial and the Zenith, ſubtract the Star's Declination from its Altitude, the Remainder is the Complement of Latitude.

Thirdly, When the Star is between the Zenith and the elevated Pole, then ſubtract the Complement of Declination from the Altitude, the Remainder is the Latitude.

The fourth Variety is ſpoke to in the fourth Variety before going; and ſo much ſhall ſerve for the Working an Obſervation; theſe Rules, if well obſerved, being ſufficient for working Obſervations in all Latitudes, whether North or South, and at all Times of the Year, as a little Practice will make evident.

It is poſſible to take an Obſervation by the Moon; but there are ſo many Things to be accounted for, as Parallax, Refraction, *&c.* and the Moon ſeldom to be ſeen, but when ſome known Star may alſo be ſeen, and I having

late. 5.

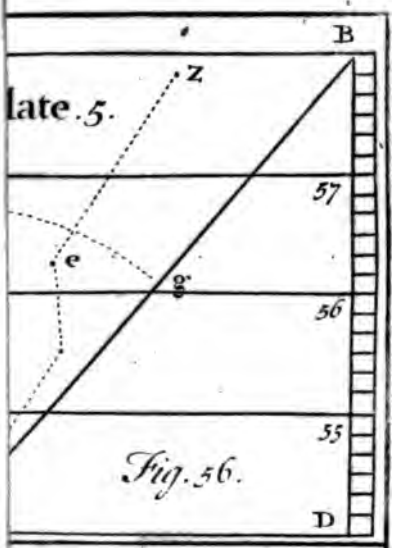


Fig. 56.

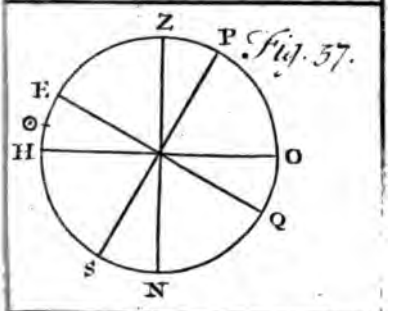


Fig. 57.

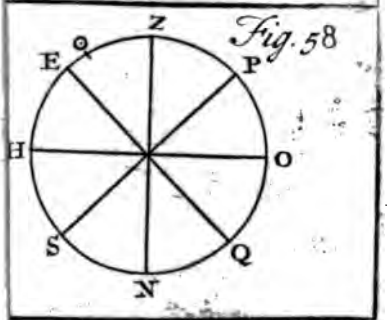


Fig. 58

plate: 1.5.

having in this Book inſerted a Table of fixed Stars, their Declinations, *&c.* I ſhall refer the Reader to it, the Sun and Stars being ſufficient in all Caſes for taking Obſervations.

SECT. V.

How to reckon the Tides.

Of the General Motion of the Tides, and how to know the Time of High-Water at any known Port, only by a Sight of the Moon at any Time of the Day or Night.

THEY that would be able to give a good Account of the Tides, or of the Time of High-Water or Low-Water, at any Port or Harbour propoſed, it is neceſſary, in order thereunto, that there be a right Underſtanding of the original Cauſe of the Motion of the Tides, or Ebbing and Flowing of the Sea; a Thing which hath been often in Diſpute among the Learned, both Mathematicians and Philoſophers, whoſe different Sentiments have rendered the Thing as dubious as when they firſt began with it; ſome aſcribing the Fluctuation of the Sea to the ſwift Motion of the Earth, according to the *Copernican* Syſtem, and that the Water being a fluid Body, and not preſently acquiring ſo ſwift an Agitation as the Earth itſelf, it muſt conſequently be higher Water upon one Part of the Globe than upon another, and this they illuſtrate thus: Suppoſe a Boat under Sail, with freſh Way, and a ſmall Quantity of Water in the Boat, it ſeems very plain, that the ſwift Motion of the Boat would make the Water incline rather towards the Stern of the Boat; but if the Boat, when ſailing with that Speed, ſhould by coming aſhore, or ſome other Accident, meet with a ſudden Interruption, and at once ſtand ſtill, the Water ſtill retaining in ſome Meaſure its former

Motion will preſently run to the fore Part of the Boat, and by this they would ſome Way or other demonſtrate, that the Motion of the Tides depends upon the Motion of the Earth: But to uſe no other Arguments for the Confutation of this Opinion, the Abſurdity hereof will appear in this; that if the Motion of the Earth were the original Cauſe of the Motion of the Tide, then the Tide muſt neceſſarily follow the Motion of the Earth, (or to our Appearance the Motion of the Sun) and conſequently it muſt always be High-Water at one Place, at one and the ſame Time of the Day; but the contrary is ſo evident to all, that there needs no more be ſaid to diſprove it.

Others ſay, the Flowing of the Tide is occaſioned by a great Confluence of Water proceeding from the Mael-ſtream, (called by ſome the Navel of the Sea, being (as it is reported) an Eddy or Whirl-pool, under the Weſt Coaſt of *Norway*, or *Finmark*, from whence (it is ſaid during the ſix Hours Flood, the Water iſſues violently out, and occaſions the Riſing or Flowing of the Water in all the adjacent Parts, and ſinks with the ſame Violence during the Ebb; ſo that it is ſaid, that during the Flood, the heavieſt Metal will not ſink; and during the Ebb, the lighteſt Subſtance, or the beſt of Ships will not ſwim; but what Reaſon they will give why this Ebbing and Flowing ſhould be regulated and governed by the Motion of Moon, I do not underſtand, unleſs this Iſſue of Water be ſupplied by ſome Communication that it hath with the *Eaſtern* Seas, by ſome Paſſage under the Main Continent of *Norway*, but this being an Uncertainty, we ſhall wave it, as well as the Opinion of a third Sort, who affirm that God, who created all Things, gave Life to all his Creatures; and that the Ebbing and Flowing of the Sea is no more but the Breathing of the Earth, which ſeems to me a very odd Fancy, and not worth inſerting, had it not been in this Collection of the various Opinions of the Learned upon this Subject. I ſhall among the reſt, deliver my own Opinion in the Matter; and although I do not think myſelf able infalliably to give a definitive Sentence in the Caſe, yet I ſhall endeavour to prove it

to

to be conſiſtent with the Obſervation and Experience of our Mariners, and ſhall anſwer what Objections can eaſily be made againſt it.

It is evident to all that own the Retundity of the Earth, (a Thing generally out of Controverſy amongſt the Learned) that there is a Principle of Graviation towards the Center of the Earth, and that this attractive Influence is diffuſed to all Beings whatſoever within the Orb thereof; and hence it is, that we that inhabit the Earth find no ſuch Thing as an upper Side and an under Side of the Earth, but in all Parts of the Superficies thereof we find a like natural Tendency towards its Centre, as it is evident by the Experience of thoſe that have ſailed about the World, and yet in their ſo far different (if not diametrically oppoſite) Places that they have ſailed to, have found themſelves and every particular Thing to have the ſame preſſing Inclination towards the Center of the Earth, which ſeemed to them to be downwards, as well as it doth to us. Now if we grant the Earth this ſtrong Principle of Gravitation, Inclination, or Attraction towards its Center, which Reaſon and common Experience proves, we have Reaſon from thence to believe, that the other Bodies, as the Sun and Moon, have the ſame Principles of Gravitation towards their Centers, (which may be proved by ſome Reaſons, which, to inſert here, would be too great a Digreſſion from the preſent Subject) which being granted, I ſuppoſe the Ebbing and Flowing of the Sea to be occaſioned by the Attraction of the Sun and Moon (eſpecially the Moon being a ſecondary Planet, which moves far nearer the Earth, and reſpect it for her Center) the Strength of which Attraction, although it cannot have any Influence upon the ſolid Part of the Earth, yet the Water being a fluid Subſtance, is more eaſily affected with this attracting Power, and by Virtue thereof, (while the Earth continues round) the Water is gently ſucked and drawn into an oval Form, by Reaſon of its inclining Tendency towards thoſe attractive Bodies, thereby cauſing High-Water where the Ends of the Oval is, and conſequently Low-Water at the Middle of the Oval, as may be demonſtrated

thus: Suppoſe two Hoops made of any flexible Subſtance, as Wood, fine Steel, *&c.* of equal Dimenſions, and laid directly one upon the other; and then if from oppoſite Points the uppermoſt were extended into an oval Form, it is evident, that as the extended Part or End of the Oval is drawn without the round Hoop, the two Sides, or Middle of it, will be contracted and pulled within it; and ſtill, as the tranſverſe Diameter of the Oval were extended and augmented, the Conjugate or ſhorteſt Diameter, will be contracted and diminiſhed; which plainly demonſtrates how the Water, when by an attractive Power it is drawn above its mean Elevation, at the End of the Oval, it muſt needs be depreſſed below its uſual Poſition at the two Places a Quarter diſtant from theſe two oppoſite Points, which Elevation and Depreſſion is the Occaſion of High and Low-Water, which happen at (near) ſix Hours Diſtance, between High and Low-Water, and confirms the Truth hereof, which is alſo evident by the following Reaſons.

Firſt, Becauſe the Motion of the Tides generally follows, and is govern'd by the Motion of the Moon; ſo that the Moon being upon one and the ſame Point of the Compaſs, makes High-Water at any particular Place, at one and the ſame Time, (unleſs accelerated, or retarded by Winds, Land floods, or the like) by which it ſeems very probable, that the Moon is the principal Agent in this regular Motion of the Sea; and if ſo, then nothing more likely than that the Influence of her attractive Power drawing the flexible Subſtance of Water into an elliptical or oval Form, as before aſſerted, is the Caſe thereof.

But Secondly, It is obſerved by all, that the Spring-Tides, (*viz.* at the New and Full Moon) are greater than the Neap-Tides (which are at the firſt and laſt Quarters) by which it ſeems evident, that although, as I ſaid in the laſt Paragraph, that the Moon is the principal moving Cauſe of the Tides, yet the Sun having alſo the like attracting Power, hath an Influence upon the Water alſo, although not ſo great as that of the Moon, (becauſe the Moon is much nearer the Earth) and is a

ſecondary

ſecondary Planet, reſpecting the Earth for her Center, and therefore, when the Sun and Moon are in Conjunction (as at the New Moon) or in Oppoſition, (as at the Full Moon) then the Tides are greateſt; becauſe the attractive Influence of the Sun is added to that of the Moon, and both raiſe the Water at one and the ſame Place, making the Spring-Tides. But at the Quarters, *viz.* when the Sun and Moon are about 90 Degrees, or a Quarter of the Zodiack diſtant, then the attractive Influence of the Sun, rather impairs that of the Moon; the one raiſing the Water where the other depreſſes it; ſo that although, for Reaſons before given, the Influence of the Moon's Attraction upon the Water is greater than that of the Sun, and therefore the Tides follow the Motion of the Moon, and not of the Sun, yet their contrary Influence leſſen the greater Influence; *viz.* that of the Moon; which is the Cauſe of the Neap-Tides; and this alſo may be illuſtrated thus: Suppoſe a Hoop of Steel, or any flexible Metal, be faſtened to any Place, if a Man with a Rope fixed to one Side thereof ſhould pull with all his Strength at the ſaid Rope, it would make the Hoop decline into an eliptical or oval Form; but if another Man, though of an inferior Strength, ſhould fix a Rope in the ſame Place where the firſt was fixed, his Strength added to the firſt would make the Ring or Hoop yet more eliptical, and would ſtretch out the tranſverſe Diameter thereof yet longer, in Compariſon of the Conjugate. But if the firſt Rope remain fixed as before, and the other managed by inferior Strength, be removed a Quarter of the Hoop's Diſtance from the firſt, then although the Ellipſes will in ſome Meaſure retain its oval Form, inclining to the ſtronger Attraction, yet the Power of the contrary Attraction will depreſs the other, and cauſe the Hoop to retain a Form at leaſt nearer to a true Circle, than as if the Attraction were all in one Place; and this plainly illuſtrates the different Attractions, cauſing different Tides, *viz.* when the attractive Powers are united their Influence is greater, cauſing the Water to be more eliptical, thereby occaſioning Spring Tides, at the New and Full Moon; but when the attractive Powers are ſeparated, as at the firſt and laſt Quarter of the Moon,

the Influence of the greater is not ſo apparent, which is at the Neap-Tide.

But my third Reaſon, Becauſe we ſee that the Spring Tides at the Equinoxes, *viz.* in *March* and *September*, are commonly higher Tides than the Sping Tides at the Solſtices, *viz.* in *June* and *December*; the Sun, and alſo the New and Full Moon, moving in or near the Equinoctial, in a right Aſpect to the Earth; whereas their Influence is ſomewhat impeded at the Solſtices, by their more oblique Poſition to the Earth. All which ſeems plainly to prove that as the Tides are regulated and governed by the Motion of the Moon, ſo her active Power, together with that of the Sun when joined with it, is the original Cauſe thereof.

Now againſt what hath been ſaid, there ſeems two grand Objections to ariſe; the firſt is, that if the Tides be governed by the Moon, and if her Attraction be the Cauſe thereof, her diurnal Motion being from Eaſt to Weſt, it would follow that the Flood-Tides ſhould in all Places ſet Weſtwards; but daily Experience proves the contrary; for it ſets in ſome Places South, as upon the Coaſt of *England*, and in ſome Places North, as upon the Coaſt of *Holland*; yea, and in ſome Places Eaſt, as in the *Britiſh* Channel, which makes againſt my former Aſſertion.

A ſecond Objection is, that if the Tides be cauſed by the Moon's Attraction, it ſhould be High-Water at all Places, when the Moon is upon the Meridian of the Place, or that a North or South Moon ſhould make full Sea in every Place; but the contrary is evident by the Tide-Tables, and by the Experience of all Sailors.

In anſwer to the firſt, *viz.* that the Flood-Tide ſhould ſet Weſtward in all Places, (the Anſwer to which will alſo partly imply an Anſwer to the ſecond, *viz.* that it ſhould always be High-Water at any Place, when the Moon is upon the Meridian of the Place) I grant that if the Tides be occaſioned as before aſſerted, then this regular Motion of the Sea, from Eaſt to Weſt, muſt neceſſarily follow, if this terraqueous Globe were equally environed with Water, and that the aforeſaid Motion of the Sea were not interrupted by the Land;

but

but it is evident, eſpecially where the Sea joins immediately upon the Weſt of any Main Continent, that the Flood cannot ſet Weſtwards there, becauſe that would be right from the Shore; as for Example, ſuppoſe the whole Land of *Europe* and *Africa* were all one Main Continent; and ſuppoſe the North Cape of *Finmark*, in about Lat. 71. North, and the South Cape of *Africa*, in about Lat. 34. South, were both under one Meridian, and that this Main Continent were terminated on the Weſt with a ſtrait Coaſt, lying under the ſame Meridian, that the two extreme Points, the North and South Capes lie under; now it is plain that the Tide cannot come from the Eaſtward upon this Weſt Coaſt; but if the Tide be cauſed by this Weſterly Motion of the Sea, according to the Motion of the Moon, it muſt ſet Weſtwards, about the North and South Parts of the ſaid Continent, and ſo proceed from the North Cape Southward, and from the South Cape Northward, along this Weſt Coaſt; and the Truth of this ſeems evident alſo from our common Experience; for we find, that the Flood proceeds from the Northward, along the Coaſt of *Norway*, and there finding a Paſſage between *Scotland* and *Norway*, marches along the Eaſt Coaſt of *England*, and hence it is High-Water ſooner in *Scotland* than in *England*, and ſooner on the Coaſt of the North Part of *England* than on the South Part; thus it is High-Water at *Aberdeen* in *Scotland*, 45 Min. after Moon's Southing, but at *Tinmouth-Bar*, not till three Hours after, and at the *Spurn* 5 Hours and 15 Min. and at *Cromer* 6 Hours, and at *Yarmouth-Pier* 9 Hours, and at *Harwich* 10 Hours 30 Min. after the Moon's Southing; the Tide, at the ſame Time being rolling along the Weſt Coaſt of *Scotland*, and from thence to the Weſt Coaſt of *Ireland*, that Paſſage between the North-Eaſt Part of *Ireland*, and the South-Weſt Part of *Scotland*, being ſo narrow, that the Tide finds little Paſſage; and therefore the Eaſt Coaſt of *Ireland* is ſupplied by a Tide which ſets Southward along the Weſt Coaſt; and hence the Tide flows Eaſtward, along the South Coaſt, and Northward along the Eaſt Coaſt thereof, as is evident by the Time of High-Water

Water obſerved in the Tide-Table; for upon the Full and Change Days, it is High-Water at *Seyn-Head* at 10 Hours 20 Minuts, from thence in 6 Hours it paſſes along the Weſt Coaſt, and butts in upon the South Coaſt, ſo that at 4 Hours 30 Minutes it is High-Water at *Kingſale*, *Cork* and *Waterford*, and from thence in 45 Minutes more, it paſſes over to *Milford*, *Lundy*, *&c.* and at the ſame Time it ſlides Northwards, along the Eaſt Coaſt of *Ireland*; ſo that in 3 Hours 45 Min. it flows from *Waterford* to *Dublin*, and in 45 Min. more to the Iſle of *Man*, *&c.* Thus the general Motion of the Tide to the Southward, having, as by a Branch proceeded from thence, filled up all the Vacancy between *England* and *Ireland*, it proceeds ſtill to the Southward, and upon the Full and Change Days, it is High-Water at the Land's End of *England* at 7 Hours, 30 Min. and in its unwearied Motion to the Southward it finds a Paſſage up the *Britiſh* Channel, and 45 Minutes after High-Water at the Land's End it is High-Water at *Portland*, and in 3 Hours 45 Min. more, it is got up to the Iſle of *Wight*, *Southampton*, and *Portſmouth*, being High-Water at the ſame Time on the other Side of the Channel, upon the Coaſt of *France*, about *Guernſey* and *Jerſey*, and ſo proceed ſlowly along the Coaſt of *France* and *Holland* ſtill to the Northward, being ſupplied by a Tide up the Channel; and this (to follow it no further) may ſufficiently prove, that the General and Original Motion of the Tide Weſtwards occaſions its Motions to the Southward along the Coaſt of *Norway*, and conſequently all its compounded Motions and Branches into the *Iriſh* Sea, the Channel, *&c.* And it is evident, that although the Tide, if not interrupted, ſhould be at the Height where the Moon is upon the Meridian; yet it finding ſo many whirling Motions to and fro between the Lands, the Moon at the ſame Time, keeping her ſtrait and uninterrupted Courſe to the Weſtward, all the Time that thoſe irregular Vacuities are filling up, it is plain, that the Moon muſt needs be paſt far from the Meridian before it can be High-Water at ſome of thoſe Places, and yet the Tide occaſioned as before aſſerted; which I think will ſufficiently anſwer the two Objections before mentioned,

and

and prove this Hypotheſis to be very conſiſtent with Reaſon itſelf, and the Experience of all Obſervers.

Now if any Body will ſtill inſiſt further upon what I hinted upon before, *viz.* That the Tide is occaſioned by a Confluence of Water ariſing at the Mael-ſtream, or Navel of the Sea, and preceding from thence, *&c.* and for Confirmation thereof will alledge that they have ſeen and obſerved this regular Riſing and Sinking of the Water (before ſpoken of) at that Place; I anſwer, I can eaſily approve of this Opinion, without denying mine own hitherto aſſerted; for they are very eaſily reconcileable; ſince it is poſſible, and very probable, that this Ebbing and Flowing at the Mael-ſtream, may be occaſioned by ſome ſubterraneous Cavern, whereby this Place hath ſome Communication with the Eaſtern Seas, and is ſupplied from thence; which being granted, it will follow, that while the Tide (whoſe general Motion is Weſtwards) is interrupted by the Continent of *Norway*, &c. and thereby is forced to find a Way about the North Cape; yet by the Way, finding this Paſſage under Ground, and the Tide, by Virtue of the Moon's Attraction, inclining that Way, there may be ſuppoſed to be ſo much Water conveyed that Way as that obſcure Paſſage can contain, though far ſhort of ſo much as to occaſion that Flowing and Ebbing that is obſerved; and this being granted, it is evident, that this Riſing and Falling at the Meal-ſtream, muſt needs keep Time with the Motion of the Moon, and of the reſt of the Tide; becauſe it proceeds from the ſame Original, and is a ſmall Brance thereof; and this we may ſee illuſtrated by our common Rivers, whoſe Natural Motion, when interrupted by Bank, or other Impediments, cauſeth the main Body of the Water to find a Paſſage ſome other Way; yet if at the ſame Time any ſmall Holes be found in the ſaid Banks, there will always ſo much Water paſs thereby as the ſaid Holes can contain; though the main Body of Water is forced another Way: Hence, from what has been ſaid, it is plain, that this ſmall Flood and Ebb obſerved at the Mael-ſtream, muſt needs have the ſame regular Motion with the reſt of the Tide, which I ſuppoſe has at firſt occaſioned, and ſince ſeemed

to

to confirm that Opinion that the Tide proceeds only from thence.

To what has been ſaid I ſhall only add, that this that I have here inſerted ſeems yet to be further confirmed by our Obſervations abroad; for it is obſerved, that there is little or no Tide at the *Straits* of *Gibraltar*, nor upon the Coaſt of *Guiney*; nor can it be expected, according to this Hypotheſis; for if the Tide comes from the Northward, it may be ſuppoſed, that by that Time that it hath paſſed ſo far along, and having ſo many Vacancies to fill up, as the *German* Ocean, the *Iriſh* Sea, the *Britiſh* Channel, the Bay of *Biſcay*, &c. its Power muſt be very much impaired, if not totally exhauſted, before it comes ſo far as the Coaſt of *Africa* before mentioned.

Now it may be queſtioned, what is the Reaſon that there is little or no Tide in the *Baltick* Sea, ſeeing there are ſtrong Tides almoſt on every Side of it, *viz.* upon the Coaſt of *Norway* on the North of it, on the Coaſt of *Holland* on the South, and on the Coaſt of *England* on the Weſt of it, *&c.*

I anſwer, it is hard to determine abſolutely what is the Cauſe thereof; but I ſhall lay down ſome Conjectures, which may conclude very much that Way; for if it was High-Water at the *Naze* and Coaſt of *Norway*, at the ſame Time that it is High-Water upon the Coaſt of *Jutland* Southward from the *Baltick* Sea, it muſt needs force a Tide into the *Baltick* Sea, as well as High-Water upon any Coaſt forces a Tide up the Inland Rivers there; but this cannot reaſonably be expected, if we conſider, that the Tide along the Coaſt of *France*, *Holland*, and *Jutland*, proceeds from the *Britiſh* Channel, and comes from thence Northwards, along the ſaid Coaſt of *Holland*, &c. but the Tide upon the Coaſt of *Norway* lies to the Southward, as hath been largely proved, the two Tides both terminating at the Mouth of the *Baltick* Sea; hence it is very probable, that it may be High-Water upon the Coaſt of *Jutland*, when it may perhaps be Low-Water, or ſome intermediate Tide at the *Naze*, or South Coaſt of *Norway*; and if ſo, it cannot force a Tide into the *Baltick* Sea, but rather a ſucking Current, or Inclination of the

the Sea from that Place on one Side of the Mouth of the *Baltick* Sea where it is High-Water, to that Coaſt on the other Side where it is Low-Water, and hence it will neceſſarily follow, that this Current muſt ſet ſometimes one Way, and ſometimes another. And this may be aſſigned as a Reaſon why many have found themſelves deceived in their Reckonings, when intending to make the *Naze*, or other Lands thereabouts; and when they have imputed their Miſtake to a Current ſetting towards the Point of the Compaſs, towards which they have found themſelves unexpectedly carried, thinking thereby to regulate their future Reckonings, they have found themſelves at another Time under a quite contrary Error, and hence have concluded that there was no Currenr at all, but ſome other Thing hath been the Cauſe of their Error; whereas, if the Tides upon the Coaſt of *Norway* and *Jutland*, *viz.* on each Side of the Mouth of the *Baltick* Sea, were carefully obſerved and determined, and the Current allowed to run or ſet from the Higheſt Water to the Loweſt, (upon which of theſe Coaſts ſoever it were) and to be at a Stand only when the Water upon both the ſaid Coaſts were of equal Height (whether Riſing or Falling) I queſtion not but that the Motion of this Current might thereby be limitted and determined, as well as the Motion of the Tides elſewhere, and due Allowance might be given for the Current there, as well as for the Ebbs and Floods in other Places, to the great Satisfaction and Advantage of thoſe that uſe the *Eaſt-Country* Trade.

This Motion of the Tide thus granted, I ſhall next ſhew how to find the Time of the Moon's Southing, and (with a little Application) the Time of High-Water by a Sight of the Moon, at any Time of the Day or Night.

How to know the Time of the Moon's coming to South, only by a Sight of the Moon, at any Time of the Day or Night.

IT is commonly known, that the New Moon being in Conjunction with the Sun, Souths at Noon, and the Full Moon being oppoſite to the Sun, comes to the South at Midnight; and at the Quarters, when ſhe is juſt half full, *viz.* to the Line N. 6. S, which croſſes the Figure directly in the Middle, then ſhe is South at 6 o'Clock, and if the light Half be on the Weſt Side N.W.S. and ſhe half full, ſhe Souths at 6 in the Evening, as at the firſt Quarter; but if the light Half be on the Eaſt-ſide, N.E.S. ſhe Souths at 6 in the Morning; which granted, the Moon's coming to the South upon any other Phaſis, or at any intermediate Age, may be eaſily gathered from the Figure, obſerving this General Rule; when you ſee the Moon at any Time of the Day or Night, obſerve how much of the Moon is light, whether on the Eaſt or Weſt-ſide, and compare it as near as you can with the Figure, conſidering to which Line in the Figure you ſuppoſe the light Part will reach, and obſerve what Number is upon that Line, for that is the Hour at which the Moon will come to the Meridian that Day or Night; as for Example; *Fig.* 61.

Suppoſe I obſerve the Moon, and find her ſomewhat more than half light on the Eaſt-ſide, ſo that comparing the Moon with the Figure, I ſuppoſe the light Part to appear like the light Part of the Figure; then I obſerve to what Number the light Part reaches, and I obſerve it reaches to the Number 5; and hence I conclude, that the Moon comes to the South about 5 o'Clock; and becauſe the light Part is on the Eaſt-ſide, I conclude it is at 5 in the Morning ſhe will be upon the Meridian.

Again, Suppoſe I ſee her in the Evening, and the light Part on the Weſt-ſide, as near as I can compute, to be like the darker Part of the Figure, towards the right Hand, then obſerving how far the light Part extends,

tends, I ſee it comes to the Figure 5, and becauſe the light Part is on the Weſt-ſide, I conclude ſhe will be South at Five in the Evening, *&c.*

And thus you obſerve the Moon two or three Days after the Change to appear in the Weſt in the Evening, with a very little Light on the Weſt-ſide, which by Computation may be ſuppoſed to come as far over the Moon's Body as the Figure 3, I conclude ſhe has been upon the South that Afternoon about Three o'Clock, and the next Night you will obſerve the Light to encreaſe, and come towards the Figure 4, I conclude ſhe was South that Afternoon between 3 and 4, or near 4, and then perhaps 5 or 6 Days after, I obſerve the light Part increaſed beyond half the Body of the Moon, as far as the Arch N. 8. S. I conclude from hence, that the Moon is South about Eight that Night; and although this Method is not ſufficient to find the Moon's Southing exactly to a Minute, yet it is of ſufficient Exactneſs for Reckoning the Tides, where a Quarter of an Hour, or Half an Hour, make no material Error, it being generally impoſſible to predict the Tides to the abſolute Exactneſs of a Minute, although you had the Moon's Southing exactly, becauſe Winds, or Land Floods, *&c.* may alter the Tides, and few that have the Charge of a Ship will truſt to the firſt or laſt Scruple of the Tide for going into an Harbour, or coming out, but will endeavour if poſſible, to have the beſt of the Tide, and to be ready for it againſt it come, whether Ebb or Flood.

The Moon's Southing being thus found, the next Thing is to ſhew how thereby to find the Time of High-Water, at any known Port; and for an Help thereunto, I have inſerted a Tide-Table, in an Alphabetical Order, in which you need but find the Name of the Port, at which you would know the Time of High-Water, and againſt it you have a Number of Hours and Minutes, which added to the Time of the Moon's Southing, gives the Time of High-Water at that Place that Day; as for Example,

Suppoſe I were lying before *Tinmouth* Bar, waiting for half Flood to go in, I happen to ſee the Moon in the Morning, and I obſerve the Eaſt-ſide of the Moon

to

to be light, like the light Part of the Figure before ſpoken of, *viz.* It is by Computation ſo much above half the Body of the Moon, that the whole light Part reacheth to the Figure 5; and becauſe the Light is on the Eaſt-ſide, I conclude ſhe is South at 5 in the Morning, then I look in the Tide-Table, in the Letter *T*, and find *Tinmouth*, and againſt it I find 3 Hours 0 Minute, which added to 5, the Time of the Moon's Southing, the Sum, which is 8 Hours 0 Min. is the Time of High-Water at *Tinmouth-Bar*; ſo that I find I may go in about 5, 6, or 7 o'Clock, with the Flood Tides according to the Draught of Water that my Ship requires.

Now it is not neceſſary, that you ſhould always have this Book or Figure about with you, for you may, with a very little Practice, get the Nature and Reaſon of it imprinted in your Memory, always remembring that the New Moon being with the Sun South at Noon, and the Full Moon being oppoſite to the Sun, ſouths at Midnight. The Moon in the firſt Quarter is South at 6 in the Evening, and at the laſt Quarter is South at 6 in the Morning. All the intermediate Times of her Age may be eaſily computed according to the Figure, exact enough for finding the Time of High-Water at any Port mentioned in the Tide-Table.

If any will object, that what hath been ſaid ſerves only for finding the Time of High-Water, at Places mentioned in the Tide-Table, but no where elſe; I anſwer, that by this Way of finding the Moon's Southing, and conſequently the Time of High-Water at any Port mentioned in the Table, together with a right Apprehenſion of the General Motion of the Tides, as you have it ſufficiently deſcribed and illuſtrated, in the Beginning of this Section, you may be able to give a very good Account of the Tide both at thoſe Places inſerted in the Table, and at thoſe that are not, provided you know but upon what Coaſt the Places are, and how ſituate from ſome known Place expreſſed in the Table, and whether they are upon the Sea Coaſt, or up ſome River, and the like; as for Inſtance, ſuppoſe coming from the Weſt of *England*, up the Channel, intending for *Bulloigne*, and not having a Tide-Table that hath the Port of *Bulloigne* expreſſed in it, I am at a Loſs to know

know how the Tide falls, ſuppoſing it at New Moon.) Now ſuppoſe in my Tide-Table, I find *Diepe* and *Dunkirk* (Ports on each Side of *Bulloigne*) and upon Examination I find it is High-Water at *Diepe*, on the Full and Change Days, at 9 Hours 45 Min. Again, I find it is High-Water at *Dunkirk* the ſame Day at 12 o'Clock; now I conclude that *Bulloigne* lying betwixt theſe two Ports hath alſo High-Water between theſe two Times, and not long after High-Water at *Diepe*, as, if you look in the Table, you will find it is High-Water at 10 Hours 30 Min. at the Full and Change.

In like Manner, if you obſerve the General Motion of the Tide to the Southward, along the Eaſt Coaſt of *England*, and to the Eaſtward, up the Channel, *&c.* you may, by knowing the Time of High-Water at any Port, very eaſily compute the Flowing and Ebbing of the Tide at any adjacent Port, and with Allowance for deep Bays, or inland Rivers, you may very nearly determine the Time of High-Water at any deſired Port.

But for Variety, and the univerſal Satisfaction of all Navigators, I ſhall inſert another (though common) Method of finding the Moon's Age and Southing, by the Epact, in order to which you muſt firſt find the Golden Number, which is thus done.

Add 1 to the Year of our Lord, and divide that Sum by 19, the Remainder is the Golden Number.

2. For the Epact, multiply the Golden Number by 11, divide the Product by 30, from which ſubtract 11, and the Remainder is the Epact for the Year propoſed,

3. For the Moon's Age add the Epact, the Day of the Month, and the Number of the Months (as expreſſed below) together, and caſt away 30 if the Sum exceeds; the Total if under 30, or the Exceſs if above 30, is the Moon's Age.

4. For the Moon's Southing, multiply the Moon's Age by 4, and divide the Product by 5, the Quotient is the Hour, and for every one that remains add 12 Min. gives the Time of the Moon's Southing.

The Number for the Months are,

0 2 1 2 3 4 5 6 and 8

8 10 and 10 theſe are the Numbers right.

That is, *Jan.* 0, *Feb.* 2, *March* 1, *April* 2, *May* 3, *June* 4, *July* 5, *Auguſt* 6, *Sept.* 8, *Octob.* 8, *Novem.* 10, *Decem.* 10.

Note; The Epact is here ſuppoſed to change the firſt of *January*.

Example.

I deſire to know the Time of High-Water at *Berwick* the 16th Day of *October* 1762.

Firſt for the Golden Number.

The Year	1762	19)1763(92
Add	1	15
Sum	1763	

The Quotient 92 is of no Uſe in this Caſe; the Remainder 15 is the Golden Number required.

To find the Epact.

The Golden Number	15
Multiply by	11
	15
	15
Which divide by	30)165(5
	15

From the Remainder (15) take 11, and the Reſidue 4 is the Epact required.

Note; If you cannot ſubtract 11 from the Remainder, you muſt add 30 to the Remainder, and then ſubtract 11 from it, and the Remainder will be the Epact required according to the New Style, but this Rule will not hold good after 1799.

For the Moon's Age.

The Epact	4
The Number for *October*	8
The Day of the Month	16
Sum	28 which is the Moon's

Age required, the Moon changing the 17th of *September*, as may be ſeen by the Table of the Moon's changing immediately following the Tide-Table.

For

For the Moon's Southing.

Multiply the Moon's Age 28 by 4, the Product 112 divide by 5, the Quotient is 22, and 2 remains, *viz.* 22 Hours and 24 Min. paſt Noon, or 24 Min. after 10 the next Morning, to which add 1 Hour 30 Min. found againſt *Berwick* in the Tide-Table, the Sum 11 Hours 54 Min. is the Time of High-Water at *Berwick*, *October* 17, 1762, in the Morning.

But becauſe the Spring Tides do not ſhift ſo much as the Neap Tides, you may yet be more exact in uſing the Table annexed.

The Uſe of this Table is very eaſy, I ſhall inſtance in the foregoing Example.

Find the Moon's Age 28 under [Moon's Age) and againſt it in the Column of [Time] you have 10 Hours 08 Min. which added to 1 Hour 30 Min. the Time found againſt *Berwick* in the Tide-Table, the Sum 11 Hours 38 Min. is the Time of High-Water required differing from the former by 16 Min. and nearer the Truth, becauſe it allows for the different ſhifting of the Tides; but either way is exact enough for common Uſe.

Moon's Age.		*Time* H.	M.
1	16	0	42
2	17	1	21
3	18	1	52
4	19	2	22
5	20	2	53
6	21	3	28
7	22	4	8
8	23	4	55
9	24	5	50
10	25	6	53
11	26	7	58
12	27	9	4
13	28	10	8
14	29	11	5
15	30	0	0

☞ *Note*; What is here ſaid of the Tides is meant as to their general Motion; the Half Tides, Quarter Tides, and Currents, being a Thing that depends ſo much upon Experience, that it is in vain to treat of them here.

A large Tide-Table after a New Method.

A	H.	M.
ABerdeen	0	45
Army	1	30
St. Andrews	2	15
Amſterdam	3	0
Armentiers	3	0
Abroth	3	15
Antwerp	6	0
Archangel	6	0
Abermorith	6	0
Amazons *River in* South America	6	0
Aldborough	9	45

B	H.	M.
BEACH	0	0
Bajador *in* Barbary	0	0
Blacktail Beacon	0	15
Blackneſs	1	30
Bell-Iſle	1	30
Berwick	1	30
Bluet *without*	2	15
Britain South *Coaſt*	3	0
Biſcay *Coaſt*	3	0
Bourdeaux *River*	3	0
Buchaneſs	3	0
Bona Eſperance	3	0
Breſt	3	45
Baſs *without*	2	45
Bridlington	3	45
Bourdeaux *River within*	3	45
Brovage *without*	3	45
Baltimore	4	30
Bree Sound	4	30
Bremen	6	0
Blackney	6	0
Briſtol	6	0
Briſtol *Key*	6	45
Bridgwater	7	30
Cape Blanco	9	45
Bulloigne	10	30
Race of Blanquet	12	0

C	H.	M.
CAPE Cantin *in* Barbary	0	0
Calais *without*	1	30
Camvere	1	30
Coquet	3	0
Cork *in* Ireland	4	30
Cape Clear *in* Ireland	4	30
Caldy	5	15
Carnarvan *Bay*	5	15
Cromer	6	0
Caſkets *without*	8	15
Cape Sierre-lion *in* Guiney	8	15
Chamberneſs	9	45
Cowes	10	30
Caen *in the* Foſs	10	30
Calais *Road*	10	30
Calſhot	11	15
Condado	12	0

D	H.	M.
DUnkirk	0	0
Dover *Port*	0	0
Port Deſire *in* America	0	0
Downs	1	30
Dundee	2	15
Denby	2	15
Dort	3	0
Dunbar	4	30
Dungarven	4	30
Dartmouth	5	15
St. David's Head	6	0
Dublin *in* Ireland	8	15
Dunnoſe	9	45
Diepe	9	45
Dunwich	9	45
Dungeneſs	9	45
Dover	10	30

E	H.	M.
EMden	0	0
Eider	0	0
Elve	0	0
Enchuyſen	0	0
Edam	1	30
Edinburgh	4	30
Egmont	4	30
Exwater	7	30
Entrance of the Emes	7	30

F	H.	M.
FLanders *Coaſts*	0	0
Fluſhing	0	45
Finmark *Coaſt*	1	30
Fountney *without*	2	15
Flamborough Head	3	0
Fair Iſle	3	0
Frith	4	30
Falmouth	4	30
Forn	5	15
Foy	5	15
Foulneſs	6	45
The Fly	7	30
Frieſland *Coaſt*	7	30
Florida *in* Carolina	7	30
Foreland *North and South*	9	45

G	H.	M.
GIbraltar *Road*	0	0
Graveling	0	0
Guernſey	0	45
Goree	1	30
Graveſend	1	30
Galicia	3	0
Gaſcoigne	3	0
Groyne	3	0
Gorend	11	15

H	H.	M.
HEver	0	0
Hern	0	0
Holy Iſland	1	30
Hartlepool	3	0
Huntcliff *Foot*	3	45
Humber *without*	4	30
Holms	6	0
Hull	6	0
Hamburgh	6	0
Hague	8	15
Harlem	9	0
Havre de Grace	9	0

	H.	M.
Harwich	10	30
St. Hellens	10	30

I	H.	M.
Jutland *Iſles*	0	0
Ireland W. *Coaſt*	3	0
Ireland South *Coaſt*	5	15
John de Luce	10	30

K	H.	M.
Kentiſh Knock	0	0
Killiars	3	0
Kinſale *in* Ireland	4	30
Kilduyn	7	30

L	H.	M.
Liſbon	2	15
St. Lucar	2	15
London	3	0
Leith	4	30
Lawreneſs	4	30
Lynn *without*	5	15
Lundey	5	15
Lynn	6	0
Lanion	6	45
Land's-end	7	30
Lizard	7	30
Lam *Bay*	8	15
Leoſtoffe	9	45
Lenow	9	45

M	H.	M.
MAZE *within*	0	45
Malden	0	45
St. Mark	2	15
St. Matthew's *Point*	3	45
Mount's *Bay*	4	30
Milford	5	15
Moonleſs	5	15
St. Maloes	5	15
Magnes *Sound*	8	15
Mecknel's *Caſtle*	8	15
Iſle of Man	9	0
Margate *Road*	11	15

N	H.	M.
NEwport *in the* Iſle of Wight	0	0
Nore Weſt End	0	0
North *C.* Maggero	3	0
Nantz *River without*	3	0
Newcaſtle	5	15
St. Nicholas *in* Ruſſia	6	45
Needles	9	45
Normandy *Coaſt*	10	30
Naze	11	15

O	H.	M.
ORkneys	3	0
Orwell	9	0
Orfordneſs	9	45

P	H.	M.
POrtſmouth	0	0
Poictou South *Coaſt*	3	0
Pens	3	0
Porthus	3	0
Portugal *Coaſt*	3	0
Plymouth	6	0

St.

	H.	M.
St. Powls	6	0
Podeſemſk *in* Ruſſia	6	45
Portland	8	15
Peterport	8	15
Picardy *Coaſt*	10	30

Q	H.	M.
Queenborough	0	0
Quebeck *in* Canada	6	0

R	H.	M.
Rebdan	0	45
Rocheſter	0	55
Rumney	1	30
Ramkins	1	30
Robin Hood's *Bay*	3	0
Rotterdam	3	0
Rovain	3	45
Rochel *without*	3	45
Roan *River within*	3	45
Ramſey	5	15
Rye	11	15
Rhodes	11	15

S	H.	M.
SHOE	0	0
Sheerneſs	0	0
Sleeve	0	0
Southampton	0	0
Spits	0	0
Shotland	3	0
Scilly	3	45
Scarborough	3	45
Sound	3	45
Staples	3	45
Severn	4	30
Seven Iſles	4	00
Stockton	5	15
Spurn	5	15
Salcomb	6	0
Start	6	45
Sedmouth	6	45
Selberg	9	0
Seven Cliffs	9	0
Shoreham	9	45
Seyn Head	10	30
Senegal	10	30

T	H.	M.
TErveer *within*	0	45
Tenet	1	30
Terveer *without*	1	30
Tinmouth	3	0
Tees Mouth	3	0
Teneriff	3	0
Torbay	5	15
Texel	7	30
Tergon	9	45

U	H.	M.
URK	0	0
Uſe	3	0
Uſhant *without*	6	0
St. Vallery	10	30

W	H.	M.
ISLE of Wight	0	0
Winchelſea	0	45
Weilands	1	30
Whitby	3	0
Waterford *in* Ireland	4	30

	H.	M.
Weymouth	6	0
Wells	6	0
Weymouth *Key*	6	45
Wieringham	7	0
Winterton	9	0

	H.	M.
Yarmouth *Road*	8	15
Yarmouth *Pier*	9	0
Yarmouth *Town*	9	45
Yarme	9	45

Y	H.	M.
Oughall *in* Ireland	4	30

Z	H.	M.
Zealand *Coaſt*	1	30
Zericke Sea	3	0

The Uſe of this Tide-Table is the ſame as in other Tide-Tables; for when you deſire to know the Time of High-water at any Place mentioned in the Table, you need but look in the Letter that the Name of the Place begins with, and there having found the Place you want, ſee what Hour and Minute ſtands againſt it, which being added to the Hour and Minute of the Moon's coming to South, the Sum (abating twelve Hours, if it exceeds) is the Time of High-Water at the Place propoſed that Day.——*Example*; I deſire to know what Time it will be High-Water at *Harwich*, *October* the 16th, 1764, I look in the Letter H, and find *Harwich*, and againſt it 10—30, which added to the Moon's Southing that Day, the Sum is 20 54, from which caſt away 12, the Remainder is the Time of High-Water: Of which ſee more in the Explanation of the following Table of the Moon's Changing.

The Uſe of the following Table of the *Moon's Changing* is ſo eaſy, that it needs little Explanation; for find the Year in the firſt Column on the Left-hand, and the Month at the Top, and in the common Angle, you have the Day and Hour of the Moon's Changing that Month.

Note; m. ſtands for *Morning*; a. for *Afternoon*. *Example*; I deſire to know the Moon's Changing in *June*, 1760: Find 1760 in the Left-hand Column, and againſt it under *June*, and find 13 8 m. that is, the Moon changes *June* 13 at 8 in the Morning; and where you find two Numbers againſt one Year, and under one Month

Years	January D.	January H.	Febru. D.	Febru. H.	March D.	March H.	April D.	April H.	May D.	May H.	June D.	June H.
1752	5	3 a	4	9m	4	9 a	3	9m	2	6 a	1 30	1m 8m
1753	4	2 a	3	10m	5	3m	3	7 a	3	8m	1	6 a
1754	13	9m	22	4m	23	10 a	22	3 a	22	4m	20	3 a
1755	12	2 a	11	5m	12	10 a	11	3 a	11	8m	9	10 a
1756	1 31	mid. noon.	None		1 30	2m 5 a	29	8m	28	mid.	27	4 a
1757	20	2m	18	1 a	20	1m	18	1 a	18	2m	16	4 a
1758	9	6a	8	4m	9	3 a	8	1m	7	10m	5	9 a
1759	28	8 a	27	7m	28	4 a	27	1m	26	9 a	24	5 a
1760	18	6m	16	8 a	17	8m	15	5 a	15	1m	13	8m
1761	6	9m	5	3m	6	7 a	5	8m	4	6 a	3	1m
1762	25	4m	23	11 a	25	4 a	24	6m	23	4 a	22	1m
1763	14	4m	12	10 a	14	5 a	13	10m	13	1m	11	2 a
1764	3	10m	2	1m	2	5 a	1	10m	1 30	3 a 7 a	29	9m
1765	21	11m	19	11 a	21	1 a	20	4m	19	8 a	18	11m
1766	11	1m	9	noon	10	10 a	9	10m	8	11 a	7	noon

Years	July D.	July H.	Auguſt D.	Auguſt H.	Sep. D.	Sep. H.	Oct. D.	Oct. H.	November D	November H.	December D.	December H.
1752	29	3 a	28	mid.	None		7	noon	6	2m	5	8 a
1753	1 30	2m 8m	28	4 a	26	mid.	26	10m	24	mid.	24	3 a
1754	20	1m	18	9m	16	4 a	16	1m	15	noon	13	11 a
1755	9	11m	7	10 a	6	8m	5	5 a	4	3m	3	1 a
1756	27	5m	25	7 a	27	7m	23	6 a	22	5m	21	4 a
1757	16	7m	14	10 a	13	1 a	13	4m	11	6 a	11	7m
1758	5	9m	3	11 a	2	3 a	2	7m	1 30	1m 5 a	30	7m
1759	24	4m	22	4 a	21	8m	21	1m	10	7 a	19	2 a
1760	12	3 a	11	1m	9	noon	9	2m	7	7 a	7	1 a
1761	2 31	8m 3 a	28	11 a	28	10m	27	10 a	26	2 a	26	8m
1762	20	8 a	19	4 a	17	mid.	17	9m	15	9 a	15	11m
1763	10	mid.	9	8m	7	5 a	7	1m	5	10m	4	9 a
1764	28	9 a	27	7m	25	5 a	25	2m	23	1 a	22	11 a
1765	18	2m	16	4 a	15	4m	14	5 a	13	4m	12	3 a
1766	7	2m	5	6 a	4	9m	4	1m	2	4 a	2 31	5m 5 a

Month, the Moon changes twice that Month; as againſt 1756, under *January*, you find { 1 : mid. / 31 : noon } that is the Moon changes twice in *January* 1756, *viz.* the firſt Day at Midnight, and the thirty-firſt Day at Noon, and ſo in the reſt: From hence you may eaſily find the Moon's Age, and her Southing, and conſequently the Time of High-Water at any Port mentioned in the Tide-Table.

Example. I would know what Time it was High-Water at *Harwich*, *March* 20, 1763. I look for the New Moon next before, and I find it was *March* 14, and hence the Moon on *March* 20 is 6 Days old, which multiplied by 4, and the Product 24 divided by 5, the Quotient is 5 for the Moon's Southing, or 4 Hours 48 Minutes after Noon, to which add 10 h. 30 m. the Hours and Minutes ſtanding againſt *Harwich* in the Tide-Table, the Sum is 16 Hours 18 Minutes, from which caſt 12, Remainder 4 Hours 18 Minutes, is the Time of High-Water at *Harwich* required.

Note; If the Moon be leſs than 15 Days old, look for her Age the Day propoſed to find her Southing; but if more than 15 Days old, look for her Age the Day before (or abate 1 from her Age the Day propoſed) and then work as before, becauſe when the Moon is above 15 Days old, ſhe comes to South above 12 Hours after Noon, which may more properly be called next Morning, and conſequently if you abate 1 from her Age found when above 16 Days old, the Southing found from thence is properly her Southing for the Morning of the Day propoſed, *&c.*

SECT. VI.

How to keep a Reckoning.

HAVING thus learned to find the Variation, and to work an Obſervation, and alſo to reckon your Tides

Tides with other Things neceſſary to be known, and having as Maſter, Mate, or Pilot of a Ship, taken your Charge for any Voyage, and having your Log-Line, Glaſſes, and other Things in Readineſs, you muſt provide *Fig.* 62. a Log-Board ruled as you ſee in the Figure.

Then having ſet Sail, and got from the Shore, and out of the Set of the Tide, obſerve how the Land bears from you that you intend to take your Departure from; and alſo, as near as you can, compute the Diſtance you are from it, and then that Courſe and Diſtance pricked off upon your Chart, gives the true Place of your Ship when you begin your Reckoning.

This done, having ſettled your Watches, and ordered a Man to the Helm for two Hours, let him obſerve carefully what Courſe he ſteers by the Compaſs, or if he ordered to ſteer upon any given Courſe, let him take Care to mind it, and at the End of two Hours let the Mate heave the Log, having one attending him with the Half Minute Glaſs, let the Mate over haul off the Line, (having firſt caſt the Log with a few Fakes of Line into the Sea) till the Red Rag come to his Hand, and at that Inſtant cry *Turn*; the Man with the Glaſs, juſt upon that Word, as the Red Rag goes away, turning the Glaſs, and watching diligently: When the Half Minutes Glaſs is juſt out, the Man that holds the Glaſs, cries *Stop*; whereupon the Mate ſtops, and hauls in the Line, obſerving exactly how many Knots, half Knots, and Fathoms are gone out, and ſets its down upon the Log-board, againſt the Hour at which the Log was heaved, and thus proceed every two Hours all the 24 Hours, and then the Log-board will be full the next Day at Noon.——Then having a Log-book ruled every Page, like the Log-board, with the Day of the Month at the Top, take off the Log into your Book, and rub out the Chalks upon the Board, ſo is the Board ready for the next Day. I ſhall inſtance in a Voyage from a Place in Latitude 54 8 North, to another Place in Latitude 57 50 North, and Difference of Longitude 8 30 ſet Sail *Auguſt* 24, at Noon, and running that Day as by the Log following.

3. *Note*;

3. *Note*; Any 24 Hours Log, from Noon to Noon, is dated by the Day upon which it ends, and not upon the Day upon which it begins; then if we ſet ſail *Auguſt* 24, that 24 Hours Log muſt be called *Auguſt* the 25th, *&c.*

The Ship having run every two Hours as you ſee in the Log on the other Side, add up all the Knots together, the Sum 47 being doubled (becauſe you heave the Log but every two Hours) is 94, to which add the 4 half Knots, which in this Caſe are accounted as 4 whole Knots, becauſe they are alſo doubled: The Sum 98 Miles is the Diſtance run that Day.——The Courſe is N.E. but becauſe there is a Point Variation Weſt, the true Courſe is N.E. by N. therefore ſet down under the Log——made good 98 Miles N.E. by N.

Then find in the Traverſe Table your Northing and Eaſting, for that Courſe and Diſtance, and ſet it in the blank Space on the Right-hand as you ſee done.

The Northing 81 5 Miles or Minutes added to the Latitude ſailed from 54 Deg. 8 Min. the Sum is the Latitude come to 55d. 29m. (the 5 which is placed after the 81 being but a Decimal, or half a Mile, need not be regarded) which ſet alſo down as you ſee.

For the Difference of Longitude you may find it by the Traverſe Table, the Middle Latitude being 55, its Complement 35 being found, and under it in the Column of Departure, find the Departure, or Eaſting 54 4 or the neareſt to; and againſt it, in the Column of Diſtance, you have 95 Min. or 1d.—35m. for the Difference of Longitude made that Day, all which ſet down as you ſee.

Now to find where your Ship is, in the firſt or laſt of the Charts before-mentioned, which are all made for this Voyage: And firſt for the firſt particular Chart; Set off 98 Miles from A, upon a N.W. by W. Line, it will reach to the Point *a*, the Place of the Ship required; or take the Difference of Latitude made that Day 81 5 in one Pair of Compaſſes; and the Departure or Eaſting 54 4 in another Pair of Compaſſes; then with

one

H.	K.	K	F.	Courſe	Winds	*Aug.* 25, 1759.
2	3			N.E.	Weſt	Variation 1 Point Weſt.
4	4					Northing —— 81.5
6	4	1				Eaſting —— —— 54.4
8	5					Lat. come to — 55*d.* 29*m.*
10	5					Diff. Longitude - 3—1.
12	5					
2	4	1				
4	4					
6	4					
8	3	1				
10	3	1				
12	3					

Made good 98 Miles North Eaſt by North.

one Foot of each Pair of Compaſſes in A, run that in which you have the Difference of Latitude along the Eaſt and Weſt Line AC, and that Pair in which you have the Departure along the North and South Line AB, the moveable Points will fall in *a* as before.

To find where the Ship is in the *Mercator*'s Chart, take the Latitude in one Pair of Compaſſes thus; ſet one Foot upon the Line *a d* in the Latitude come to 55 29, which is at the Point *q*, and extend the other to any Parallel, as ſuppoſe the Line 55 55; then after the ſame Manner take the Longitude in your Compaſſes, running them parallel to any North and South Line, the meeting

meeting of their moveable Points, *viz.* at *x*, is the Place of the Ship required.—— *Note*; The Place of the Ship at *x*, in the third Chart is found by either of the two Methods by which it is found in the firſt.

How to keep Account of a Ship's Way upon a Wind.

A Ship is ſaid to ſail upon a Wind, when her Tacks are aboard, and her Yards ſharp braced, and is commonly ſuppoſed to be within ſix Points of the Wind with Lee-way, according to the Sail ſhe carries, *viz.*

All Sails ſet —— 1			Try under Mainſail only —— 5
A Topſail in —— 2			Under Mizen only 6
Both Topſails in and a Sea —— 3	}	Points	{ Lie a Hull, all Sails furled —— 7
Try under Mainſail and Mizen —— 4			

According to theſe Allowances of Lee-way, I ſhall work the following Examples; nevertheleſs, in Practice, Lee-way muſt be allowed according to Judgment, for ſome Ships make more Lee-way than others, with the ſame Sail ſet, *&c.*

This Example, *Auguſt* 26, hath two Courſes, which muſt be reduced to one by the Rules for working a Traverſe by the Traverſe Table.—The firſt Courſe is N.E. by the Compaſs, but by the Variation allowed, *viz.* one Point Weſt, it is N.E. by N. but the Wind being N.N.W. *viz.* within ſix Points of the Courſe, we muſt allow one Point Lee-way from the Wind, which brings it again to N.E.

For the Diſtance, add up the firſt ſix Number of Knots, during which Time ſhe lay upon that Courſe, the Sum 21 doubled, and the two half Knots added, makes in all 44 Miles N.E. for the firſt Courſe.

The

The ſecond Diſtance by the ſame Rule, is 39 Miles, the Courſe by the Compaſs N.W. but a Point Variation Weſt makes it N.W. by W. and a Point Lee-way, which is alſo Weſterly, makes the Courſe made good to be W.N.W. the Diſtance 39 Miles.

Courſe	Diſt.	North	South	Eaſt	Weſt
N.E.	44	31—1		31 1	
W.N.W.	39	14—			36 0
		46 0			31 1
					4 9

By Traverſe Sailing as performed by the Table, you find the Northing 46. 0. and the Weſting 4.9, and by Caſe the ſixth of Plane Sailing, by the Traverſe Table, the Diſtance made good is 49 Miles North, 6 Degrees Weſt; all which ſet down as in the firſt Day's Work: Then add this Days Northing to the Northing got before, the Sum 127.5 is the Total Northing. Alſo ſubtract this Weſting 4.9 from the Eaſting got before, the Remainder 49.5 is the Total Eaſting, both which ſet down as you ſee; alſo by adding 46 Minutes to the laſt Day's Latitude, the Sum 56.15 is the Latitude come to.

The Difference of Longitude is 9 Min. which becauſe it is Weſt, it is to be ſubtracted from the Longitude the Day before, and the Remainder 1d. 22m. is the Longitude come to.

Now to find where the Ship is, upon the firſt and laſt Charts, take the Total Northing in one Pair of Compaſſes, and the Total Eaſting in another Pair, and proceed as before from A, the Place ſailed from, it ſhall produce the Point *e*, for the Place arrived at: Alſo in the ſecond, which is a *Mercator's* Chart, find the Longitude and Latitude come to by the Method preſcribed in the firſt Day's Work, and their Meeting or Interſection is at the Point *e*, the Place of the Ship required.

Note; In the firſt and laſt Charts you may ſet off one Courſe and Diſtance, by another, as in Traverſe Sailing Geometrical; but I ſhall not inſert that Way, leſt it too much confuſe the Draught.

How

H.	K.	½K	F.	Courſe	Winds
2	3			N.E.	NNW
4	3	1			
6	4				
8	4				
10	3	1			
12	4				
2	3	1		N. W.	NNE.
4	3	1			
6	3	1			
8	3	1			
10	3				
12	3				

Auguſt 26. 1759.

Variation 1 Point Weſt
Northing —— 45.7
Weſting —— —— 4.9
Total Northing — 127.2
Total Eaſting —— 49.5
Latitude come to — 56.15
Diff. Longitude — 0.9 W
Long. come to —— 1.31

Made good 46 Miles North, 6 Degrees Weſterly.

How to correct a Reckoning by an Obſervation.

IN the following Day's Work, *Auguſt* 27, there is made good 116 Miles; the Courſe with Variation allow'd is N.E. by N. and the reſt as you ſee found by the foregoing Method.

It is needleſs to give any more Examples of allowing for Lee-way or Variation, the Rule being the ſame when Lee-way is 4, 5, 6, or 7 Points, as when it is but one Point, only minding to allow as much as it is, and the right Way. Thus if a Ship lie North with Wind at E.

E.N.E. and 6 Points Lee-way, ſhe makes her Way good at W.N.W. *&c.*

My Reckoning at Noon, *Auguſt* 27, brings me into Latitude 57, 51; but by Obſervation which I muſt prefer before the Dead Reckoning, I find I am in Latitude 57, 34; now to correct the Reckoning by an Obſervation, obſerve this General Rule.

If your Difference of Latitude be { more / leſs } than the Depart. the Fault is more likely to be in the { Log of Diſt. / Co. or Courſe }

The Reaſon of the General Rule above, is evident from the Figure; for ſuppoſe a Ship at A ſail South Eaſterly, till by his Reckoning he is at C, or in the Latitude of the Parallel B C, but by Obſervation he is in the Parallel of Latitude D, E, F: Now if we will ſuppoſe his computed Diſtance A C to be right, ſweep the Arch A C till it cut the Parallel D F in F, and make A F equal to A C: Now by this Means the Line A F is the Line deſcribed by the Ship's Motion, whereas we thought it had been the Line A C; but it is abſurd to think that any ſhould be ſo far miſtaken in their Courſe as to ſteer from A to F, when he thought he had been ſteering from A to C; and therefore we muſt impute the Fault to the Diſtance, ſuppoſing that the Miſtake lies there, and that when he thought he had ſteered from A to C, his Reckoning was a-head of the Ship, and that when he ſhould have been at C he was only at E, the Space E C being but a tolerable Miſtake in the whole diſtance A C. *Fig.* 63.

But in a more Eaſterly (or Weſterly Courſe) ſuppoſe a Ship ſail from A till his Courſe and Diſtance by Dead Reckoning is repreſented by the Line A I, and the Latitude come to by the Parallel G I, but by Obſervation he is in the Parallel of Latitude H L K: Now if he were ſuppoſed to keep a right Account of his Courſe, and the Fault to be in the Diſtance, we muſt continue the Line A I till it cut the Parallel H K, and allow him to be the whole Diſtance I K, miſtaken in his Account,

H.	K.	½K	F.	Courſe	Winds
2	3	1		N.E.	Weſt
4	4				
6	4	1			
8	5				
10	5				
12	5	1			
2	6				
4	6				
6	5	1			
8	4	1			
10	4	1			
12	4				

Aug. 27, 1759.

Variation 1 Point Weſt.

Northing	96.4
Eaſting	64.4
Total Northing	223.6
Total Eaſting	113.9
Latitude come to	57.51
Diff. Long. Eaſt.	1.53
Long. come to	3.25
Lat. by Obſer.	57.34
Tot. Eaſt. correct.	105.2
Tot. North. cor.	206.9
Long. come to cor.	3.9

Made good 116 Miles North Eaſt by North.

which is abſurd, and therefore imputed the Miſtake to the Courſe; and then with one Foot of the Compaſſes in A, with the Extent A I deſcribe the Arch I L, and draw the Diſtance A L equal to A I, and ſuppoſe that when he thought he had ſailed along the Line A I, he had indeed ſailed along the Line A L, the Angle I A L being a much more tolerable Fault in the Courſe, than the Diſtance I K could be ſuppoſed to be in the Diſtance.

Note; If you ſail in a Current you may eaſily be groſly miſtaken, either in Courſe or Diſtance; but of that ſee more at the latter End of this Book.

Now in this Example the obſerved Latitude, *Aug.* 27, differs from the Latitude by Reckoning the Quantity

of

of 17 Miles or Minutes, and becauſe the Total Northing is more than the Total Eaſting, I impute the Fault to the Diſtance by the Log, and then it is corrected by this Proportion.

As the Total Northing 223.6, to the Total Eaſting 113.9, ſo the Error in the Northing 17 to the Error in the Eaſting 8.7 neareſt.

113.9
17
797.3
1139
1936.3

223.6)1936.3(8$\frac{1}{2}\frac{7}{3}\frac{5}{6}$
174

or 8.7 Miles neareſt, to be ſubtracted from the Total Eaſting 113.9 the Remainder 105.2 is the Total Eaſting correct.

The Reaſon of this Proportion is evident from the Diagram; for in the Triangle A B C, as the Total Northing by Reckoning A B, to the Total Eaſting by Reckoning B C, ſo the Error in the Northing E *q*, to the Error in the Eaſting *q c*; for the Sides of the Triangle A B C, and E *q c*, are proportional; by *Eucl. Lib.* 6. *Prob.* 4.

Then to correct the Longitude; As the proper Difference between the Latitude by Reckoning, and the Latitude by Obſervation, to the Meridional Difference between the ſame two Latitudes, ſo the Error in Departure, to the Error in Longitude, that is, as 17 to 32, ſo 8.7 to the Error, in Longitude.

32
8.7
22.4
256
278.4

17)278(16
108
··6

Minutes, (rejecting the Fraction, being but a Fraction of a Minute, to be ſubtracted from the Longitude by Dead Reckoning, the Remainder 19.35 is the true Longitude Correct by Obſervation.

But in Caſe your Courſe be far Eaſterly or Weſterly, and the obſerved Latitude differs from that found by the Dead Reckoning, it is beſt to correct only the Latitude, reducing it to the obſerved Latitude, and not to

meddle at all with the Departure or Difference of Longitude, becauſe the Error is too ſmall; as in the foregoing Figure the true Departure H L differs ſo little from the Departure found by Dead Reckoning G I, that it is not worth while to correct it, unleſs you have ſome certain Obſervation of Longitude to correct it by.

When you have thus corrected your Latitude, Departure, and Difference of Longitude for this Day at Noon, as here *Aug.* 27, and proceed to the next Day's Work, add the next Day's Northing to the Northing correct this Day, to find the Total Northing next Day, and not to the Northing found by Dead-Reckoning; and do the ſame alſo with the Departure and Difference of Longitude, not regarding that found by Reckoning; and ſo proceed as before; and when you get another Obſervation to correct your Reckoning by, add up only the Northing and Eaſting made good ſince the laſt Obſervation, and not of the whole Voyage, and ſo correct again according to this Example.

Now for ſetting off that Day's Work, *Aug.* 27, upon each Chart, the Method is to be uſed that was before directed to, and the Point Z in each Chart, ſhall repreſent the Place of the Ship, *Auguſt* 27, at Noon.

Now if you deſire to know the Courſe and Diſtance from the Ship to the Place propoſed, it may be done eaſily and exactly upon the two laſt Charts, and chiefly upon the laſt of all the three; for in it you need but ſet one Foot of the Compaſſes in the Point Z, where the Ship is, and the other Foot in the Point B, the Place bound for; that Extent applied to the graduated Line B D, accounting every Degree 60 Miles, and every ſmall Diviſion 10 Miles, gives the true Diſtance required 53 Miles.

In the ſecond Chart, which is according to Mr. *Wright's* Projection, commonly called *Mercator's*, if you uſe the Method which you have there preſcribed, for finding the Diſtance of any two Places upon a *Mercator's* Chart Geometrically, you will find it exactly agreeing with the former, *viz.* 53 Miles.

For finding the Courſe, the Method is the ſame in both; for the Rumbs are right Lines, equally divided, or

at

at equal Diſtances in both Charts; therefore if your Charts have the Rumbs upon them, obſerve which Rumb a Line drawn from the Ship to the Port would be parallel to, for that is the Courſe required; but if you would ſtill be more exact, you may find the true Courſe and Diſtance from the Ship to the Port, by Caſe the Sixth of *Mercator's* Sailing Trigonometrical thus, (having both Latitudes and Longitude given)

	Lat.	Long.
The Ship when correct by Obſervation is in	57·34	3 9
The Port bound for is in —— ——	57·50	8 30

Proper Diff. Lat. 16 Merid. Diff. Lat. 30
Diff. Long. 5.21 or 321.

As Merid. Diff. of Latitude ——	30 ——	1.47712
To Radius —— —— ——		10.00000
So Diff. of Longitude ——	321 ——	2.50650
To Tang. of the Courſe ——	84.40 ——	11.02938

Then for the Diſtance.

As Sine Comp. Courſe — S.C. —	84.40 ——	8.96825
To proper Diff. of Latitude ——	16 ——	1.20412
So is Radius —— —— ——		10.00000
To the Diſtance —— ——	172 ——	2.23587

The Courſe is North 84.40 Eaſt, and the Diſtance 172 Miles.

But here we may ſee the intolerable Error of the Plane Chart, the Ship being at ☓, and the Port bound for at the Point ⊙, the Extent between them being applied to the graduated Line 16. 16, and allowing 60 Miles to each Degree, gives a Diſtance vaſtly too great from the Ship at ☓ to the Port ⊙, a moſt unſufferable Error.

I know it is objected by ſome, that notwithſtanding what can be ſaid againſt the Plane Chart, it is ſtill the moſt uſeful and frequent among us, witneſs a great Part of the Charts and Waggoners that are now extent, both in *Dutch* and *Engliſh*, and if the Plane Chart was ſo groſly falſe in ſo ſhort a Voyage as between the two Places before propoſed, it would ſeem that thoſe Plane Charts and Waggoners ſhould not be ſo much

The Ship having ſailed from Latitude 54.8. to Latitude 57.34, the proper Difference of Latitude is 206, and the Meridional Difference of Latitude is 368, and Departure made good is 105.2.

			Co. Ar.
Therefore As proper Diff. of Lat.	— 206	———	7.68614
To Merid. Diff. of Lat.	— 368	———	2.56584
So Departure	——— 105.2	———	2.02201
To Diff. of Longitude	— 188	———	2.27399

Difference of Longitude 188 Min. or 3 Deg. 8 Min. the Longitude come to, differing but one Minute from what is found by the Traverſe Table, although that is found at three Operations.

And now, ſeeing I have in the former Part of this Book laid down Methods for the working the ſeveral Caſes and Queſtions in Navigation, and keeping a Reckoning both in Longitude and Latitude, not only by given Numbers, which I have called *Arithmetical Navigation*, but alſo without any Books, Tables, or Inſtruments, by a New Method never yet known, nor publiſhed; I ſhall inſtance in the firſt Day's Work in both Ways of Operation, it being too tedious to inſtance in all the three Day's Works, eſpecially ſeeing there are ſufficient Examples given of each Method elſewhere; and firſt by the given Numbers in Arithmetical Navigation.

The Courſe that Day is N.E. by N. 98 Miles.

The given Number for three Points to find	Diff. Lat. is	———	8315
	Departure is	———	5556

For

For Difference of Latitude.	For the Departure.
98	98
83	555
294	490
784	490
81|34 Diff. of Lat. 81.3.	490
It ſhould be 81.5, but the Error is only $\frac{2}{100}$, and is occaſioned by omitting the two laſt Figures of the given Number.	54|390

The Departure or Eaſt 54.39, or rather 54.4.

Difference of Latitude 81.3, or 1 Deg. 21 Min. hence the Latitude come to is 55 Deg. 29 Min.

For the Difference of Longitude, the Middle Latitude is 45.48, but the next greater whole Degree is 55, whoſe given Number in the ſecond Table is 5735, but I ſhall only uſe the firſt two Figures 57.

Departure with Cyphers —— 57)5440(95 The Diff. of Long. 95m. or 1d. 35m. the Remainder being but a Fraction of a Minute, we reject it.
Given Number, or Diviſors —— 310
25

The ſame Day's Work caſt up by a New Method.

The Courſe 33.45 or 33 $\frac{3}{4}$, the Diſtance 98 Miles.

For the Natural Radius for 33 $\frac{3}{4}$ Deg. by Method the Second, they that can work by croſs Multiplication need not redude the Fraction to a Decimal, but ſquare it as follows;

$33\frac{1}{4}$
$33\frac{1}{4}$

33 by 33 is — 1089
$\frac{1}{4}$ of 33 is — $24\frac{1}{4}$
The same again $24\frac{1}{4}$
$\frac{1}{4}$ of $\frac{1}{4}$ we reject.

$1138\frac{1}{2}$
3

$3.41\,5\frac{1}{2}$
57.3

Nat. Rad. — 60.7

As 60.7 to 98 : : $33\frac{1}{4}$ to Departure

$33\frac{1}{4}$

294
2943
7

3307

60.7)3307.0(54.4
272.0
292.0

492

For Diff. of Lat. by Rule the Third
Sum of the Sides 1534
Diff. of the Sides 436

9144
4572
6016

Product — 6644.64(81.5 Square Root of the Product and Difference of Latitude required.
64
161)244
161
183 1

For Difference of Longitude, the Complement of Middle Latitude is 35, its Natural Radius is 61 : Therefore as 35 to 54.4 so 61 to Difference of Longitude.

54.4
61

54.4
3264

3318.4

35)3318(94$\frac{28}{35}$
168

28

or 95 Minutes, or 1 Degree 35 Minutes, the Difference of Longitude required.

And thus you see the Excellency and Usefulness of this New Method, by which, although by Stress of Weather or Cruelty

Cruelty of Enemies, you had loſt all Charts, Books, Tables and Inſtruments, yet you may without any of them keep as juſt an Account of your Ship's Way, both in Longitude and Latitude, as you can with them; as this and other Examples inſerted elſewhere in this Book make manifeſt.

CHAP. VIII.

SECT. I.

How to make an Orthographick Projection of the Sphere, commonly called the Analemma; whereby, moſt of the neceſſary Queſtions in Aſtronomy may be reſolved without Trigonometrical Calculations, only by the Help of Scale and Compaſſes.

ALTHOUGH I have inſerted all the Aſtronomical Tables, ready calculated, that are of Uſe in the Practice of Navigation, and have alſo laid down a Method for finding the Variation of the Compaſs, without Azimuth or Amplitude, *&c.* yet for the Sake of ſuch as delight in Aſtronomical Operations, I ſhall ſhew the Learner how to ſolve all neceſſary Aſtronomical Queſtions by the Analemma, or Orthographick Projection upon the Plane of the Meridian; and in this Manner of Projection, the Eye is ſuppoſed to be perpendicular

dicular to that great Circle upon whoſe Plane the Projection is made, and at an infinite Diſtance from the ſaid Circle: ſo that any Line let fall from the Eye upon any Place within the ſaid Circle, ſhall be perpendicular to the ſaid Plane, and then will the Primitive Circle (or Meridian of the Place, when the Projection is upon the Plane of the Meridian) be a perfect Circle. All right Circles that divide the Projection into two equal Parts are ſtrait Lines, or Diameters, of the Primitive Circle; and all Oblique Circles that divide the Primitive into two equal Parts, and yet touch it at oppoſite Points are Semi-Ellipſes, or Half Oval Circles; and all Parallels, or leſſer Circles, are right Lines, cutting the Primitive into two unequal Parts; and Parts of Lines that ſerve for the Solution of any Aſtronomical Queſtions, are Parts of ſome of thoſe Circles, or ſuppoſed to be ſo, and are meaſured or projected according to the following Directions.

The Primitive Circle (being drawn with the Chord of 60 Degrees of any Radius large or ſmall) any Parts of it is meaſured upon the Chords of the ſame Radius. Any Part of a Right Circle is meaſured upon the Sines. Any Part of an Oblique Circle (when required to be meaſured, which is but ſeldom) may be meaſured on the Chords, being firſt reduced to the Primitive Circle thus; draw two Lines through the two Points in the Oblique Circle, the Diſtance between which is to be meaſured, and let the ſaid two Lines be drawn parallel to that Right Circle which cuts the ſaid Oblique Circle at Right Angles, and mark where theſe two Parallels cut the Primitive Circle, and the Diſtance between theſe two Marks meaſured on the Chords, is the Meaſure of the Oblique Circle required.

Note; There is no Way to project theſe Oblique Circles, but by finding a great Number of Points through which they are to paſs, and ſo by a ſteady Hand, or Help of a Bow, draw it through the ſaid Points; but the Operation being tedious, and of little Uſe, it is ſeldom put in Practice: Nevertheleſs I ſhall hereafter ſhew how they are done, as alſo all the reſt, as in the following Example.

An Orthographick Projection of the Sphere upon the Plane of the Meridian. For

Latitude of *London* — 51 —— 32
Sun's Declination North — 22 —— 30

Firſt, With the Chord of 60, draw the Circle P E S Q, to repreſent the Meridian; then draw the Diameter H O to repreſent the Horizon, and at Right Angles to it draw the Line Z N, to repreſent the Prime Vertical; then ſet off the Latitude 51 32 (taken off the Chords) from *o* to P, and from H to S, and draw the Line P R S to repreſent the Axis of the World, P the North Pole, and S the South Pole: Then at Right Angles with the Line P S, draw the Line E Q to repreſentt the Equator: Then ſet the Chord off the given Declination 22 30 from E to D, and from Q to C, and draw the Line D C the Parallel of the Sun's Declination: Set off the Chord of 23.30, the Sun's greateſt Declination from E to T and from Q to K, and draw the Line T K to repreſent the Ecliptick: Set off alſo the Chord of 23.30 from P to *q* and *g*, and draw the Line *q g*, to repreſent the Artick Circle, and the ſame from S to *r* and *v*, and draw the Line *r v* to repreſent the Antartick Circle: Then from P, through the Point ⊙ draw the Meridian P *h* ⊙ B; thus, herein given is this Meridian the Point P and the Point ⊙; then to find the Point B, another Point through which this Meridian is to paſs, divide the Line E R after the ſame Proportion that the Line D F is divided, at the Point ⊙, that is, as F D to F ⊙, ſo R E to R B, and make the Mark B, and by the ſame Means find the Point *h* in the Line *q g*: Then through the Points P *h* ⊙ B with a Bow, Curving or Bending gradually, draw the pricked Curving Line P *h* ⊙ B to repreſent a Part of another Meridian: All which being finiſhed you may proceed to anſwer the following Problems. *Fig.* 65.

1. *To*

1. *To find the Sun's Longitude or Diſtance from the next Equinoctial Point.*

The Sun's Longitude, or Diſtance from the next Equinoctial Point, is an Arch of the Ecliptic, contained between the Center R (or Interſection of the Ecliptic and Equator) and the Point ⊙, (the Interſection of the Ecliptic and Parallel of Declination) ſo here R ⊙ meaſured on the Sines, is the Sun's Diſtance from the next Equinoctial Point.

2. *Of the Sun's Right Aſcenſion.*

It is an Arch of the Equator, contained between the Equinoctial Point R, and the Point where the Meridian drawn through ⊙ cuts the Equator, as in G, ſo R G meaſured on the Sines, gives the Right Aſcenſion required.

Note; If it be thought too much Trouble to draw theſe Meridians, all theſe Problems, which can be done by the Help of the Meridians, may be done without them, if you reduce the leſſer Circles to the common Radius; therefore F ⊙ is the Sine of the Sun's Right Aſcenſion to a leſſer Radius F D; which may be reduced to the common Radius thus: Suppoſe I would find the Sun's Right Aſcenſion, ſet F D from R to *d*, upon the Line R H, then with the Extent F ⊙, and one Foot in *d*, deſcribe the Arch *e*; a Ruler laid from R, by the Extremity of that Arch will cut the Primitive Circle in *e*; then H *e* meaſured on the Chords is equal to F ⊙, the Sun's Right Aſcenſion required.

Note; When any Arch of a leſſer Circle is to be meaſured, it muſt be firſt reduced to the common Radius, and meaſured as before.

3. *To find the Hour of the Day.*

The Hour from Six o'Clock is an Arch of the Parallel of Declination, contained between the Line P S and the Point ⊙, which reduced to the common Radius, and meaſured as in *Problem* the ſecond, gives the Degrees of a great Circle, which allowing 15 Degrees for an Hour, and

and one Degree to 4 Minutes of Time, gives the Hour from 6.

4. *To find the Time of the Sun's Riſing and Setting.*

The Arch F *y* reduced to the common Radius by *Prob.* II. and the Degrees reduced to Time by *Prob.* III. gives the Hour that the Sun riſes before 6, or ſets after 6.

Note; If the Sun had 22d. 30m. South Declination, it muſt have been repreſented by the Parallel *f m*, and then the Arch *b i* reduced as before, would have given the Time of the Sun's Riſing after, or Setting before 6 o'Clock.

5. *To find the Length of the Day or Night.*

That Part of the Parallel of Declination which is above the Horizon, reduced as in *Prob.* II. and III. and doubled gives the Length of the Day, and that Part which is below the Horizon gives the Length of the Night: Thus D *y* gives the Length of the Day, and *y c* the Length of the Night when the Sun hath 23d. 30m. North Declination, and *f h* gives the Length of the Day, and *h m* the Length of the Night in the ſame South Declination.

6. *To find the Sun's Amplitude.*

The Sun's Amplitude is an Arch of the Horizon contained between the Eaſt or Weſt Point, and the Point where the Sun riſes or ſets: Thus R *y* is the Amplitude in North, or R *h* in South Declination, which becauſe it is an Arch of a great Circle is meaſured on the Sines.

Note; The Amplitude is always of the ſame Denomination with the Declination, whether North or South.

7. *To find what Hour the Sun will be due Eaſt or Weſt.*

The Sun is Eaſt or Weſt when in the Line ZN, and it is 6 o'Clock when the Sun is in the Line PS, therefore the Arch XF, reduced by *Prob.* II. and III. gives the Hour after 6 in the Morning, that the Sun is due Eaſt, or 6 in the Evening that it is due Weſt.

8. *To find the Sun's Altitude when Eaſt or Weſt.*

The Arch R X meaſured on the Sines, gives the Sun's Altitude when Eaſt or Weſt.

9. *To*

9. *To find the Sun's Altitude at 6 o'Clock.*

The Arch F W equal to R *a*, meaſured on the Sines, gives the Sun's Altitude at 6.

10. *To find the Sun's Azimuth at* 6.

The Arch *a* F, reduced by *Prob.* II. gives the Azimuth at 6 required, accounting the Azimuth from the Eaſt or Weſt; but if from the North the Arch F *n* reduced as before anſwers the *Problem.*

11. *To find the Sun's Azimuth at any given Hour: As ſuppoſe 5 in the Morning, or 7 at Night.*

I have thought fit to inſert this *Problem*, not only for its Uſefulneſs, but becauſe it is performed by another Method of reducing a leſſer Circle to the common Radius, which is the Inverſe of that Way of reducing, mentioned in *Prob.* II. As for Example, Becauſe 5 in the Morning is one Hour before 6, and every Hour of Time is equal to 15 Degrees of a greater (or leſſer) Circle; therefore ſet off 15 Degrees from F towards *y*, which is done thus.

Set off F C from R to *d* upon the Line R H; ſet off 15 of the Chords from A to *g*, and draw the pricked Line R *g*, the neareſt Diſtance from the Point *d*, to that Line ſet from F to *l* is 15 Degrees, or an Hour of Time in that leſſer Circle, and the Point *l* is the Place of the Sun at 5 in the Morning, and the Arch *b l* reduced to the common Radius by *Prob.* II. gives the Sun's Azimuth from the Eaſt Northwards at 5 in the Morning, or from the Weſt Northwards at 7 in the Evening; and by this Method you may ſet off any Number of Degrees upon any Parallel or leſſer Circle, a Thing of great Uſe in Orthographick Projection.

SECT.

SECT. II.

Of the Stereographic Projection of the Sphere, upon the Plane of the Meridian.

STereographick Projection of the Sphere (as well as Orthographic) is a Branch of Perſpective; in this the Eye is ſuppoſed to be placed in the Pole of that great Circle, upon whoſe Plane the Projection is to be made; but in the Pole oppoſite to that Half that is to be projected, the ſeveral Circles ſuppoſed to be transferr'd to a Plane biſecting the Sphere in the Circle upon which the Projection is made, and this Projection hath this Excellency, that no other Preſpective Projection is capable of; for upon this all Circles of the Sphere greater or leſſer, (except right Circles) are alſo Circles upon the Plane of the Projection, and will anſwer the Appearance, and the Laws of Projecting and Meaſuring as well without the Primitive Circle as within it, which makes this Projection more commodious and more practiſed than any other. *Fig.* 65.

In this Kind of Projection there are four Sorts of Circles, *viz.* The Primitive Circle, a Right Circle, an Oblique Circle, and a Parallel Circle.

1. The Primitive is a perfect round Circle, upon whoſe Plane the Projection is made; and in this Caſe it is the Meridian of the Place; as here the Circle ZHNO is the Primitive Circle.

2. A Right Circle is a ſtrait Line, or Diameter of the Primitive Circle which cuts the Primitive in two oppoſite Points, and divides it into two equal Parts, as HAO is the Horizon, or EAQ the Equator, *&c.*

3. An Oblique Circle cuts the Primitive at two oppoſite Points, but divides it not into two equal Parts, as Z ⊙ N, an Azimuth, or P ☉ S, a Meridian.

4. A Parallel Circle is a leſſer Circle, neither cutting the Primitive in oppoſite Points, nor dividing it in

two equal Parts, as $q \odot F$, a Parallel of Declination, or $B \odot C$, a Parallel of Altitude.

PROB. I. *How to find the Center of any Circle.*

1. The Primitive Circle is always drawn with the Chord of 60 Degrees, upon the Center A.

2. A Right Circle, (being a ſtraight Line) hath no Center.

3. The Center of an Oblique Circle always falls in that Right Circle, which cuts the ſaid Oblique Circle in two equal Parts; thus the Center of the Circle $Z \odot N$ falls in the Right Circle H A O, and the Center of the Circle $P \odot S$ falls in the Right Circle E A Q; and if you have three Points, as $Z \odot N$, through which the Circle is to paſs, the Center is found by the ſixth Geometrical *Problem* at the Beginning of this Book; but if you have given the Angle that the Oblique Circle is to make with the Primitive Circle, ſet the Tangent of the Angle from the Line H A O, or with the Secant of the ſaid Angle, and one Foot in Z or N, with the other croſs the Line H A O, either Way you ſhall find the Center of the Oblique Circle required.

4. For the Center of a Parallel Circle, having its Diſtance from the Right Circle, to which it is parallel, given, ſet off the Chord of that Diſtance upon the Primitive Circle from each End of the Right Circle, and the half Tangent of the ſaid Diſtance from the Center A, upon that Right Circle, which cuts the other at Right Angles, and ſo you have three Points, through which the Parallel is to paſs, to find its Center by the ſixth Geometrical Problem.

Or thus, Suppoſe I would find the Center of the Parallel of Declination $q \odot F$, ſet the Tangent of the Complement of the Sun's Declination from q or F, or the Secant of the ſame from A upon Line S A P continued, and that ſhall find the Center required.

PROB.

PROB II. *To find the Pole of any Circle.*

Note; The Pole of any great Circle is always 90 Deg. from it's Periphery: Therefore,

1. The Pole of the Primitive is always at its Center A.

2. The Pole of a Right Circle is always in the Primitive, as the Pole of the Right Circle H A O is at Z, and the Poles of the Right Circle E A Q are at P and S, *&c.*

3. For the Pole of an Oblique Circle, as ſuppoſe the Circle Z ⊙ N, obſerve where the ſaid Oblique Circle cuts the Right Circle, which it cuts at Right Angles, as here in the Point G, lay a Ruler from Z to G, it cuts the Primitive in *y*; ſet off 90 of the Chords from *y* to K, a Ruler laid from Z to K, cuts the Circle H A O in *g*, the Pole of the Oblique Circle required.

4. The Pole of a Parallel Circle is always in the Pole of that Right Circle to which it is parallel; thus the Pole of the parallel *q* ⊙ F is at P, the Pole of the Right Circle E A Q, *viz.*

Note; An Arch of a Parallel Circle is never made a Side of a Spherical Triangle, they being all compoſed of Arches of Great Circles, whether Primitive, Right or Oblique.

PROB. II. *To Project any given Angle.*

1. To make an Angle of 23 30 at the Center of the Primitive with the Right Circle E Q.

Set 2330 of the Chords from E to *q*, and from Q to W, and draw the Line or Right Circle *q* W, it makes (at A the Center) the Angle required.

2. To draw an Oblique Circle to make at Z an Angle of 48 Degrees with the Primitive.

The Center of this Circle will fall in the Right Circle H A O by *Prob.* I. Set the Tangent of 48 the given Angle from A towards O, it will reach to *r*, then upon *r*, as a Center with the Extent *r* Z or *r* N draw the Oblique

lique Circle Z G N, it will make at Z the Angle required.

3. To draw an Oblique Circle to make a given Angle at the Primitive with another Oblique Circle, as ſuppoſe I would draw an Oblique Circle, to make at P an Angle of 48 Degrees with the Oblique Circle P *t* S.

Lay a Scale from P to *t* (the Point where the Oblique Circle cuts the Right Circle in which its Center falls) and it will cut the Primitive in *v*, ſet the given Angle 48 off the Chords from *v* to *x*, a Scale laid from P to *x* will cut the foreſaid Right Circle in *w*, draw the Circle P *w* S by Prob. I. it is the Oblique Circle required.

4. To project any given Angle within the Primitive, but not at the Center.

We ſhall add this general Rule to what was laid down Prob. I. *viz.* that as I ſaid there the Centers of all Oblique Circles fall in that Right Circle, which cuts them as Right Angles, I ſhall now add, that the Centers of all Oblique Circles that paſs through the ſame Point in the Right Circle, fall in a right Line drawn through the Center of the ſaid Oblique Circle, and at Right Angles with the ſaid Right Circle. *Example*, Becauſe the Point *r* is the Center of the Oblique Circle Z G N, therefore the Centers of all Oblique Circles that paſs through the Point G, ſhall fall in the Line *c d* continued, which paſſes through the Point *r*, and cuts the ſaid Circle at right Angles, *&c.* which being well underſtood the Application is eaſy; as for Inſtance, it is required to draw an Oblique Circle through the Point G in the Right Circle HAO, to make with the ſaid Right Circle an Angle of 55 Degrees.

Lay a Scale from Z to G, it will cut the Primitive in *y*, the Arch H *y* meaſured on the Chords is 48 Degrees, (the Meaſure of the Angle H Z G) therefore ſet the Tangent of 48 from A to *r*, and through *r* at Right Angles to the Right Circles H A O draw *c d* continued, then with any Radius, and one Foot in G draw the Arch *f* R, and from the ſame Radius ſet off 35 Degrees (the Complement of the Angle to be made at G) from *f* to *i*; a Scale laid from G to *i* will cut *c d* in *m*, with the Extent *m* G, and one Foot in *m*, deſcribe the Oblique Circle SGP,

it

it is the Circle required, and makes the given Angle 55 at G, with the Right Circle H A O.

Theſe Directions, with the Rules for meaſuring Arches of Circles and Angles, which follow in Order, will be ſufficient to inſtruct the Learner in projecting any Angle required to be made by a given Oblique Circle, with another Oblique Circle to be projected, and through a given Point in the ſaid Circle; but there is in this Caſe another Variety, which is,

To draw a Right Circle to make with an Obliqce Circle any given Angle; in order to the Underſtanding of which, this general Rule may be neceſſary, *viz.*

That the Diſtance between the Poles of any two great Circles (meaſured upon a great Circle drawn between the ſaid Poles) is equal to the Angle made by the Interſection of the ſaid Circles, are conſequently to project the ſaid given Angle is but the reverſe of the former; for having found the Pole of the given Oblique Circle, draw a Parallel Circle about the ſaid Pole diſtant from it, equal to the Quantity of the Angle propoſed, and where that Parallel cuts the Primitive ſhall be the Pole of the Right Circle, from which ſet off 90 Degrees both ways upon the Primitive, theſe Points, and the Center ſhall be three Points in a right Line, through which the Right Circle is to be drawn, and wherever it interſects the Oblique Circle, it makes the Angle required to be made, but that Interſection is confined to that Point of Interſection only; but as we have not yet taught how to draw a Parallel to an Oblique Circle at any given Diſtance from it, it ſhall next follow.

PROB. IV. *To draw a Parallel to an Oblique Circle at any given Diſtance from it.*

It is required to draw a Circle parallel to the Oblique Circle P *b* S 30 Degrees diſtant from it's Pole.

Find the Pole of the Oblique Circle by *Prob.* II. which will be found at *ſ*, lay a Scale from S to *ſ*, it will cut he Primitive in *l*, ſet 60 Degrees (the Parallel's Diſtance from the Pole of the Oblique Circle) both Ways

from *l* to P, and *v* a Scale laid from S to P will cut E *q* in A, which happens at or near the Center of the Circle, alſo a Scale laid from S to *v* will cut Q E (continued) in *s*; the Space *s* A being divided equally in *t*, with the Extent *s t* or A *t*, and one Foot in *t* deſcribe the Circle *s* Z A, it is the Parallel required, and *f* its Pole is alſo the Pole of the Oblique Circle P *b* S to which it is parallel.

PROB. V. *To ſet off any Number of Degrees, upon a Great Circle.*

In this Problem are three Varieties.

1. To ſet off any Number of Degrees upon the Primitive, ſuppoſe 51 deg. 32 min. from O upwards.

Take 51 32 of the Chords, and with that Extent and one Foot in O, the other will reach to P, the Arch O P being 51 32, as required.

2. To ſet off any Number of Degrees upon a Right Circle; ſuppoſe 22 30 from the Center A towards P.

Take the half Tangent of 22 30, and ſetting one Foot in A the other will reach to *b*, and the Arc A *b* is 22 30 required, and *b* P its Complement to 90, *viz.* 67, 30.

Note; If you ſet off any Number of Degrees upon a Right Circle from the Center, you muſt account from the Beginning of the half Tangents, and reckon forwards; but if you begin at the Primitive, you muſt alſo begin at 90 of the half Tangents and reckon backwards; thus if you had to ſet 67 30 from P, you muſt take 67 30 backwards, *viz.* from 90 to 22 30, which will reach to *b*, as before.

But if you have any Degrees to ſet off upon any intermediate Arch between the Center and the Periphery, it is ſomething more difficult; but the following Rule is univerſal in all Varieties of this Problem.

Set the Chord of 22 30 from E towards Z, it will reach to *q*, lay a Scale from Q to *q* it will cut P S in *b*, then is A *b* 22 30, as was required.

PROB.

PROB. VI. *How to meaſure any Side of a Triangle or Arch of a Great Circle.*

1. Any Arch of the Primitive is always meaſured upon the Chords.

2. Any Arch of a Right Circle is always meaſured upon the half Tangent.

3. Any Arch of an Oblique Circle is meaſured thus;

Lay a Ruler from the Pole of the ſaid Oblique Circle, over the Extremities of the ſaid Arch, and obſerve where it cuts the Primitive, and that diſtance meaſured on the Chords gives the Quantity of the Arch required.

Example. Suppoſe I would meaſure the Arch ⊙ G of the Circle, Z ⊙ N: Lay a Ruler from *g* (the Pole of the ſaid Circle) to ⊙, it cuts the Primitive in B: Again, a Ruler laid from *g* to G cuts the Primitive in H; the Diſtance BH, meaſured on the Chords, gives the Quantity of the Arch ⊙ G required.

PROB. VII. *How to meaſure any Spherical Angle.*

This one Rule is univerſally uſeful in all Caſes (whether the Sides including the Angle be Arches of the Primitive, Right or Oblique Circle) *viz.* Lay a Rule from the Angle, over the Poles of the two Circles, including the Angle, and obſerve at what two Places the Ruler cuts the Primitive, ſet that Diſtance meaſured on the Chords, gives the Quantity of the Angle required.

Example. I would meaſure the Angle Z ⊙ P of the Triangle Z P ⊙: Lay a Ruler from ⊙ to *g* (the Pole of one of the Circles including the Angles) it cuts the Primitive in B, and then a Ruler laid from ⊙ to *o* (the Pole of the other Circle including the Angle) it cuts the Primitive in *q*; the Arch *q* B meaſured on the Chords, gives the Quantity of the Angle Z ⊙ P required.

By theſe Directions, and the Inverſe of them, you may ſet off any Number of Degrees, or lay down any Angle required, as will be further illuſtrated in the following Example, the Room aſſigned for this Subject not permitting me to enlarge upon it.

A Stereographick Projection of the Sphere, upon the Plane of the Meridian. For,

	d.	m
Latitude of *London* —— ——	51	32
Sun's Declination —— ——	22	30

How to project the Sphere ſtereographically upon the Plane of the Meridian.

Firſt with the Chord of 60 Degrees, and one Foot of the Compaſſes in the Center A, deſcribe the Primitive Circle ZHNO to repreſent the Meridian; draw the Diameter HAO to repreſent the Horizon, and at Right Angles to it, draw the Diameter ZAN the Azimuth of Eaſt and Weſt: Then becauſe the Pole is 51d. 32m. above the Horizon, ſet of 51d. 32m. of the Chords from O to P, and from H to S, then is P the North Pole, and S the South Pole: Draw the Diameter SP, the Axis of the World, and Hour Line of 6, and at Right Angles to it, the Diameter EQ the Equator; Alſo becauſe the Sun's Declination is 22d. 30m. draw the Parallel of Declination q ⊙ F, at 22d. 30m. Diſtance from the Equator Northward, by *Prob.* I. hereof. Now the Sun being in the Parallel q ⊙ F, and alſo in the Ecliptick q ⊙ w, it muſt be at the croſſing of thoſe Circles, *viz.* at the Point ⊙, which is the true Place of the Sun in the Projection, which being found you have three Points, Z, ⊙, N, thro' which to draw the Azimuth, Z ⊙ N, and 3 Points P ⊙ S, through which to draw the Meridian P⊙S, both which are done by *Prob.* I, hereof; and then the Parallel q ⊙ F is the Paralel deſcribed by the Sun's Motion, that Day the Sun Riſing and Setting at g, and at Six o'Clock at h, and Eaſt or Weſt at m, and upon the Meridian at q, *&c.* which is ſo intelligible, that it needs no further Illuſtration.

For

For the Ecliptick, ſet off 23d. 30m. (the Sun's greateſt Declination) from E to *q*, and from Q to W, and draw the Diameter *q* W, which ſhall repreſent the Ecliptic.

By *Prob.* I. hereof draw the Meridian P *m* S, and the Azimuth Z *b* N; and through the Point ⊙ (where the Ecliptick cuts the Parallel of Declination) draw the Meridian P ⊙ S.

1. *To find the Sun's Longitude or Diſtance from the neareſt Equinoctial Point.*

The Arch of the Equator A ⊙, meaſured on the half Tangents, and the Degrees and Minutes found reduced to Sines, Degrees and Minutes of the Ecliptic, allowing 30 Degrees to a Sine, *&c.* gives the Sun's Longitude required.

2. *To find the Sun's Right Aſcenſion.*

The Arch of the Equator A *t* meaſured on the half Tangents, gives the Sun's Right Aſcenſion when he is in *Aries*, *Taurus*, or *Gemini*; but if in *Cancer*, *Leo*, or *Virgo*, the Degrees ſo found ſubtracted from 180, gives the Right Aſcenſion; and when the Sun is in *Libra*, *Scorpio*, or *Sagittary*, the Degrees ſo found added to 180, gives the Right Aſcenſion; but if in *Capricorn*, *Aquarius*, or *Piſces*, the Degrees ſo found ſubtracted from 360, ſhews the Right Aſcenſion required.

Note; For finding the exact Degrees and Minutes of the Sun's Right Aſcenſion, the ſame Rules of adding and ſubtracting the Degrees found, are to be uſed in the Orthographick Projection alſo.

3. *To find the Hour of the Day.*

Obſerve where the Meridian P ⊙ S cuts the Equator, as in *t*, the Arch A *t* of the Equator meaſured on the half Tangent, and reduced to Time, allowing 15 Deg. to an Hour, *&c.* gives the Hour paſt 6 in the Morning, or the Hours wanting of 6 at Night.

Or

Or thus: In the Oblique Triangle Z P ⊙, the Angle at P, meaſured by *Prob.* IV. and reduced to Time as above, gives the Hours wanting of 12, if in the Forenoon; or the Hours paſt 12, if in the Afternoon.

4. *To find the Time of the Sun's Riſing and Setting.*

Through the Point *g* (where the Parallel of Declination cuts the Horizon) draw the Meridian P *g* S, and obſerve where it cuts the Equator, as in *b*, the Arch A *b* meaſured on the half Tangents, and the Degrees reduced to Time, give the Hour and Minutes that the Sun riſes before Six in the Morning, or ſets after Six in the Evening; or if in South Declination, where the Parallel of Declination interſects the Horizon on the other Side of the Line PS, or Hour Line of 6, it gives the Sun's Riſing after 6, or Setting before 6, *&c.*

5. *To find the Length of the Day or Night.*

The Hour and Minute of the Sun's Setting doubled gives the Length of the Day, the Time of the Sun's Riſing doubled gives the Length of the Night.

6. *To find the Sun's Amplitude.*

The Arch of the Horizon A *g* (being an Arch contained between the Sun's Riſing or Setting at *g*, and the due Eaſt or Weſt Point at A) meaſured on the half Tangents gives the true Amplitude from the Eaſt or Weſt required.

7. *To find what Hour the Sun will be at Eaſt or Weſt.*

The Sun is Eaſt or Weſt in *m*, the Point where the Parallel of Declination cuts the Prime Vertical, or Eaſt and Weſt Line Z A N; therefore having drawn the Meridian P *m* S, obſerve where it cuts the Equator, as at *w*, then A *w* meaſured on the half Tangents, and reduced to Time, gives the Hour after Six in the Morning that the Sun is due Eaſt, or the Hour before Six in the Evening that the Sun is due Weſt.

8. *To*

8. *To find the Sun's Altitude when Eaſt or Weſt.*

The Arch A *m*, meaſured on the half Tangents, anſwers the Queſtion, and gives the Sun's Altitude when Eaſt or Weſt.

9. *To find the Sun's Altitude at Six o'Clock.*

The Sun is in the Point *b* at Six o'Clock, therefore the Arch *b e* meaſured by *Prob.* III. gives the Sun's Altitude at 6 required.

10. *To find the Azimuth at Six o'Clock.*

The Arch of the Horizon A *e*, meaſured on the Half Tangents, gives the Sun's Azimuth from the Eaſt or Weſt required, whoſe Complement to 90 in the Azimuth from the North, *&c.*

11. *To find the Sun's Azimuth at any Hour or Altitude, as ſuppoſed when in the Point* ⊙ *in this Projection.*

From Z to N, and through the Point ⊙, draw the Azimuth Z ⊙ N, as before directed, and obſerve where it cuts the Horizon as in G, then the Arch A G meaſured on the Half Tangents, gives the Azimuth from the Eaſt or Weſt required.

Thus have I given you a Taſte of all the moſt uſeful *Problems*, relating to the Orthographick and Stereographick Projection of the Sphere; of which I ſhall add no more at this Time, but proceed to Spherical Trigonometry, and its Application to Practical Aſtronomy, in their proper Places.

SECT.

SECT. III.

Of Spherical Trigonometry.

AS Plane Triangles, conſiſt of three right-lined Sides and three Angles, made by their interſecting each other, ſo Spherical Triangles are made by the Interſection of the Arches of three great Circles of the Sphere, and of thoſe there are three Sorts, *viz.* Right-angled, Oblique, and Quadrantal, but the two firſt Kinds are moſt in Uſe; and as the great Circles of the Sphere are either Meridians, Azimuths, *&c.* when they interſect each other ſo as to make a Spherical Triangle, the Solution of ſuch Triangles is what is generally called Aſtronomy.

In Spherical Triangles obſerve theſe Solutions.

1. Each Triangle hath 6 Parts, *viz.* 3 Sides and 3 Angles.

2. In Right-angled Triangles there are 5, called Circular Parts, *viz.* the two Legs and Hypotenuſe, and 2 Acute Angles, the Right Angle being not looked upon as any Part in this Caſe.

3. Of theſe five there are always two given and one required (theſe two and Radius being ſufficient to find out the fourth Term required) and of theſe three there is always one called Middle Part, and the other two are either Conjuncts, or Disjuncts, *viz.* either both next Middle Part, or both ſeparated from it by a Part, not mentioned in the Queſtion, as in the Scheme, ſuppoſing in the Pentagon AB C D E, if A B and E were the Parts mentioned (whether given or required) A would be Middle Part, and
Fig. 81. B and E would be Conjuncts, but if D A and B were given, D would be Middle Part, and A and B Disjuncts, and if this be underſtood of the Pentagon, it may be as readily underſtood of a Triangle;
Fig. 82. for ſuppoſe the three Sides, B, C and E, and the two Angles A and D, all which are called Circular Parts, were any three of them the Parts given or required; as for Inſtance, if B, C and D, then C would be Middle Part, and

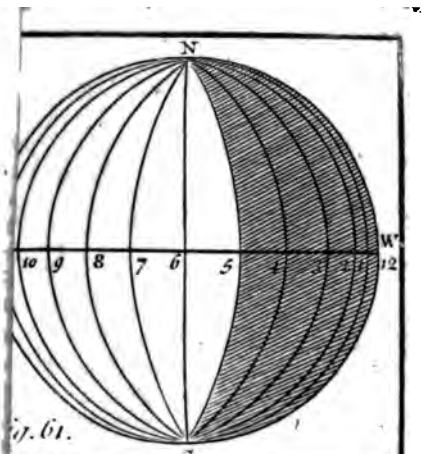


Fig. 61.

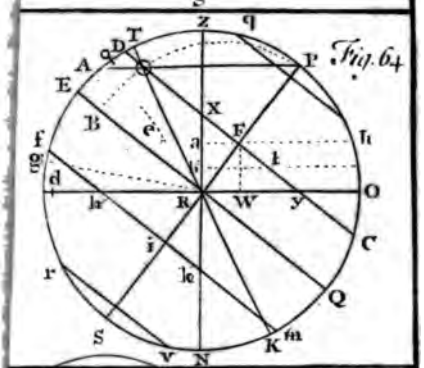


Fig. 64

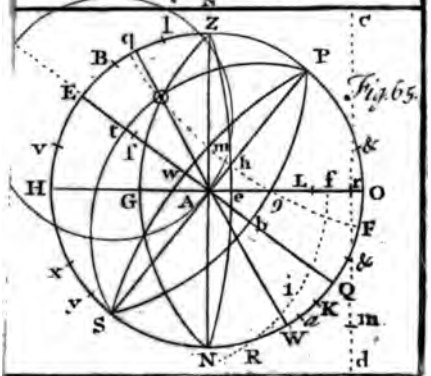


Fig. 65.

and B and D Conjuncts, or if AB and D were the Parts given or required, A would be Middle Part, and C and D Disjuncts, becauſe B is between A and C, and E is between A and D, *&c.*

4. Then the fundamental Proportion is, *As Radius to Tangent of one Conjunct, ſo Tangent of the other Conjunct to Sine of the Middle Part.*

And, *As Radius to Sine Complement of one Disjunct, ſo Sine Complement of the other Disjunct to Sine of Middle Part* ——*Only*——

5. The Hypotenuſe and two Acute Angles, *viz.* A and D are called by their Complements, that is, if any of them are Middle Parts, it is called Sine Complement inſtead of Sine, or if Conjuncts, they are called Tangent Complement inſtead of Tangent, and conſequently of Disjuncts, they are called Sine, inſtead of Sine Complements, *viz.*

6. As in the fundamental Proportion, Middle Part is the laſt Term, it will follow that if Middle Part be given, and a Conjunct required, the Proportion muſt be inverted, *viz.* *As Tangent of the given Conjunct to Radius, ſo is Sine of Middle Part to the Tangent of the required Conjunct*, &c. Underſtand the ſame of Disjuncts.

7. In all Spherical Triangles the Sines of the Sides are Proportional to the Sines of their oppoſite Angles, *viz.* as Sine of D to Sine of B, ſo Sine of A to Sine of C, and ſo Radius to Sine of E, *&c.* *Fig.* 82.

8. Oblique Triangles may be brought under the foregoing Rules by letting fall a Perpendicular, and working it as two Right-angled ones, only obſerve to *Let your Perpendicular fall from the End of a given Side, and oppoſite to a given Angle*, which when done, all the twelve Caſes in Oblique may be performed by theſe Rules, and the following Concluſions.

CONCLUSIONS.

1. The Co-ſines of the Angles at the Baſe are directly proportional to the Sines of the Vertical Angles.

2. The

2. The Sines of the Baſes and Tangents of the Angles at the Baſe are reciprocally proportional.

3. The Co-ſines of the Segments of the Baſe, and Co-ſines of the Hypotenuſes are in direct Proportion.

4. The Tangents of the Hypotenuſes are reciprocally proportional to the Co-ſines of the Vertical Angles.

5. The Tangents of the Baſes are proportional to the Tangents of the Vertical Angles.

6. In all Oblique Spherical Triangles, when a Perpendicular is let fall from the greateſt Angle to the greateſt Side, it will be, as Tangent of half the Baſe to Tangent of half the Sum of the Sides, ſo Tangent of half the Difference of the Sides to Tangent of half the Difference of the Segments of the Baſe; which half Difference being added to the half Baſe, the Sum is the greater Segment, but ſubtracted from it, the Remainder is the leſſer Segment.

Theſe are ſufficient for all the 28 Caſes, yet for Variety I ſhall inſert another Operation where three Sides are given to find an Angle, *viz.*

Add the three Sides together, and from their half Sum, ſubtract the Side oppoſite to the Angle required; then to the Complement Arithmetical of the Log-Sines of the containing Sides, add the Log-Sines of that half Sum and Remainder, half the Total of theſe four Logarithms is the Sine Complement of half the Angle required.

Theſe Directions well underſtood, being ſufficient to ſolve all the 28 Caſes of Spherical Triangles, I ſhall give a brief Inſtance of each Caſe, to help the Memory as well as the Underſtanding of the Learner, and ſhall apply them more largely when I come to ſpeak of Aſtronomy itſelf.

Note; I ſhall for Brevity ſake put *S.* for Sine, *S. C.* for Sine Complement, *T.* for Tangent, *T. C.* for Tangent Complement, *R.* for Radius; and ſhall only mention the Proportions there, and ſhall perform the Calculations from the ſame Reaſons afterwards; *Note*, Mark the given Parts with a Daſh thus ′, the required thus o.

CASE

CASE I. *Fig.* 83.

Given { Angle A / Hyp. AD } Required AB.

Here by the foregoing Directions, A is Middle Part, and AD and AB are Conjuncts, and though Middle Part is a Sine, yet being an Angle its becomes a Sine Complement, alſo AD being a Conjunct ſhould be a Tangent; but being the Hypotenuſe, it is a Tangent Complement, likewiſe becauſe Middle Part is given, the fundamental Proportion muſt be inverted, all which being conſidered, the Analogy is,

As *T. C.* AD to *R.* ſo *S. C.* A to *T.* AB.

CASE II. *Fig.* 84.

Given the Hypotenuſe and an Angle, to find the Leg oppoſite to the given Angle.

Given { The Angle A / Hypotenuſe AD } Required BD.

Here B D is Middle Part, and AD and A are Diſjuncts, therefore the Proportion is,

As *Rad.* to *S.* AD, ſo *S.* A to *S.* BD.

CASE III. *Fig.* 85.

Given the Hypotenuſe and an Angle, to find the other Angle.

Given { Hypotenuſe AD / The Angle A } Required the Angle D.

Here

Here A D is Middle Part, and the Angles A and D are Conjuncts, therefore the Proportion is:

As *T. C.* A to Rad. *S. C.* AD to *T. C.* D.

CASE IV. *Fig.* 86.

Given the Hypotenuſe and a Leg, to find the Angle included between them.

Give { Hypot. AD / Leg AB } Required the Angle A.

The Angle A is Middle Part, and A D and A B are Conjuncts, therefore the Proportion is:

As Rad. to *T.* AB, ſo *T. C.* AD to *S. C.* A.

CASE V. *Fig.* 87.

Given the Hypotenuſe and a Leg, to find the Angle oppoſite to the given Leg.

Given { Hypot. AD / Leg AB } Required the Angle D.

Here AB is Middle Part, and AD and D are Disjuncts, therefore the Proportion is:

As *S.* AD to Rad. ſo *S.* AB to *S.* D.

CASE VI. *Fig.* 88.

Given the Hypotenuſe and a Leg, to find the other Leg.

Given { Hypot. AD / Leg AB } Required BD.

Here

Here A D is middle Part, and A B and B D are Disjuncts, therefore the Proportion is:

As *S. C.* AB to Rad. ſo *S. C.* AD to *S. C.* BD.

CASE VII. *Fig.* 89.

Given an Angle and a Leg adjacent, to find the Leg oppoſite to the given Angle.

Given { Angle E / Leg E F } Required the Leg F G.

In this Caſe EF is middle Part, and the other Parts are Conjuncts, therefore the Proportion is:

As *T. C.* E to Rad. ſo *S.* EF to *T.* FG.

CASE VIII. *Fig.* 90.

Given an Angle and a Leg adjacent, to find the Angle oppoſite to the given Leg.

Given { Angle F / Leg E F } Required the Angle G.

Here the Angle G is middle Part, and E F and E are Disjuncts, therefore the Proportion is:

As Rad. to *S. C.* EF, ſo *S.* E. to *S. C.* G.

CASE IX. *Fig.* 91.

Given an Angle and a Leg adjacent, to find the Hypotenuſe.

Given { Angle E / Leg E F } Required EG.

The Angle E is middle Part, and EF and EG are Conjuncts, therefore the Proportion is:

As *T.* EF to Rad. ſo *S. C.* E to *T. C.* EG.

CASE X. *Fig.* 92.

Given an Angle and a Leg oppoſite, to find the Leg adjacent to the given Angle.

Given $\left\{\begin{matrix}\text{Angle E}\\ \text{Leg FG}\end{matrix}\right\}$ Required E F.

The Side EF is middle Part, and Angle E and Side FG are Conjuncts, therefore the Proportion is:

As Rad. to *T.* FG, ſo *T. C.* E to *S.* EF.

CASE XI. *Fig.* 93.

Given an Angle and a Leg oppoſite, to find the Angle adjacent to the given Leg.

Given $\left\{\begin{matrix}\text{Angle E}\\ \text{Leg FG}\end{matrix}\right\}$ Required Angle C.

Here E is middle Part, and FG and Angle G are Diſjuncts, therefore the Proportion is:

As *S. C.* FG to Rad. ſo *S. C.* E to *S.* G.

CASE XII. *Fig.* 94.

Given an Angle and a Leg oppoſite, to find the Hypotenuſe.

Given $\left\{\begin{matrix}\text{Angle E}\\ \text{Leg FG}\end{matrix}\right\}$ Required E G.

Here F G is middle Part, and E G and Angle E are Diſjuncts; therefore

As *S.* E to Rad. ſo FG to *S.* EG.

CASE

CASE XIII. *Fig.* 95.

Given the Leg to find an Angle.

Given { Leg HI / Leg IK } Required Angle H.

Hence HI is middle Part, and IK and H are Conjuncts, hence the Proportion is:

As *T.* IK to Rad. ſo *S.* HI to *T. C.* H.

CASE XIV. *Fig.* 96.

Given the Legs to find the Hypotenuſe.

Given { Leg HI / Leg IK } Required HK.

Hence HK is middle Part, and HI and IK are Disjuncts, therefore the Proportion is:

As Rad. to *S. C.* HI, ſo *S. C.* IK to *S. C.* HK.

CASE XV. *Fig.* 97.

Given the Angle to find a Leg.

Given { Angle H / Angle K } Required HI.

Here the Angle K is middle Part, and HI and Angle H are Disjuncts, therefore the Proportion is:

As *S.* H to Rad. ſo *S. C.* K to *S. C.* HI.

CASE XVI. *Fig.* 98.

Given the Angle to find the Hypotenuſe.

Given { Angle H / Angle K } Required HK.

Here HK is middle Part, and the Angle H and K are Conjuncts, therefore the Proportion is:

As Rad. to *T. C.* H, ſo *T. C.* K to *S. C.* HK.

Theſe are the 16 Caſes of Right-angled Triangles, and are all performed by the fundamental Proportion, commonly called my Lord *Napier*'s, mentioned in Solution the 4th, by the Help of the Direction in Solution 2, 3, 5, and 6; the other 12 Caſes are in Oblique, and performed by Solution 7 and 8, and the Concluſions following them.

Note; When we refer to any Caſe, we mean ſome of the 16 Caſes of Right-angled Spherical Triangles before going.

Oblique Angels.

CASE I. *Fig.* 99.

Two Sides and an Angle oppoſite to one of them being given, to find the Angle oppoſite to the other.

Note; It is to be known whether the Angle required be Acute or Obtuſe; for if it be Acute, the Sine, Tangent, *&c.* that the Operation produceth, is the Sine, Tangent, *&c.* of the Angle required; but if it is Obtuſe, the Degree found ſubtracted from 180, the Remainder is the Degrees of the Angle required.

Given { The Side LN, The Side NM, The Angle M } Required the Angle L.

The Solution of this depends upon, *viz.*

As *S.* LN to *S.* M, ſo *S.* NM to *S.* L.

CASE

CASE II. *Fig.* 100.

Two Sides being given with an Angle oppoſite to one of them, to find the Angles included between the given Sides.

Given { The Side L N / The Side NM / The Angle M } Required the Angle N.

Let fall the Perpendicular NP from N by Sol. 8. it falls within by Sol. 9. then in the Right-angled Triangles MPN there is given the Side NM, and the Angle M to find the Angle MNP by Caſe III. and then by Concluſion the fourth, the Proportion for finding the Angle LNP is:

As *T.* LN to *S. C.* MNP, ſo *T.* MN to *S. C.* LNP, and the Angle LNP being found and added to the Angle MNP, the Sum is the whole Angle LNM required.

CASE III. Fig. 101.

Given two Sides and an Angle oppoſite to one of them, to find the third Side.

Given { The Side LN / The Side NM / The Angle M } Required the Side LM.

Here, as in Caſe II. becauſe the ſame Things are given, the Perpendicular muſt fall from the Angle N, upon the Side LM, and having let it fall to P by Sol. 8. you have given in the Right-angled Triangle MPN the Angle M and Side MN, to find the Baſe MP by Caſe I. which being found, find the other Segment of the Baſe by Concluſion the third, *viz.*

As *S. C.* NM to *S. C.* PM, ſo *S. C.* LN to *S.* LP.

Then MP, added to LP, the whole Side is the Side LM required.

CASE IV. *Fig.* 102.

Two Angles and a Side oppoſite to one of them being given, to find the Side oppoſite to the other.

Note; Here, as in Caſe I, it is required to be known whether the Side required be more or leſs than a Quadrant; for if it be leſs, the Sine or Tangent found anſwers the Caſe; but if it is more than a Quadrant, ſubtract the Degree and Minute found from 180 Degrees, the Remainder is the Angle required.

Given { The Angle N / The Angle M / The Side L N } Required the Side LM.

The Proportion in this Caſe deduced from Sol. 7. is:

A *S.* M to *S.* LN, ſo *S.* N to *S.* LM.

CASE V. *Fig.* 103.

Two Angle and a Side oppoſite to one of them being given, to find the Side included between the given Angle.

Given { The Angle N / The Angle M / The Side L N } Required the Side LM.

Here by Sol. 8. the Perpendicular is to fall from the Angle N upon the Side LM, and then in the Triangle LPN there is given the Angle L, and the Side LN to find the Baſe L P by Caſe I. of Right-angled Spherical Triangles, which being found, the other Segment PM is found by Concluſion the ſecond, thus:

As *T.* M to *S.* LP, ſo *T.* L to *S.* MP.

The Segment MP added to LP makes the whole Side LM required.

CASE

CASE VI. *Fig.* 104.

Given two Angles and a Side oppoſite to one of them, to find the third Angle.

Given { The Angle L, The Angle M, The Side L N } Required the Angle N.

The Perpendicular falls from the Angle N by Sol. 8. then in the Right-angled Triangle LPN there is given the Angle L and Side LP, to find the Angle LNP by Caſe III. and then the other Angle MNP by Concluſion the firſt, thus:

As *S. C.* L, to *S.* LNP, ſo *S. C.* M, to *S.* MNP.

Then the Angle MNP added to LNP is the whole Angle LMN required.

CASE VII. Fig. 105.

Two Sides and an Angle included given, to find either of the other Angles.

Given { The Side XY, The Side YZ, The Angle XYZ } Required the Angle Z.

Here by Sol. 8. the Perpendicular muſt fall either from X or Z, and by Sol. 9. it falls without either upon the Side XY continued, or upon ZY continued, but where the Caſe is ſo ambiguous by Sol. 8. obſerve;

Let the Perpendicular fall from the End of a given Side, and oppoſite to a given Angle, and likewiſe oppoſite to the Angle required, if an Angle be required, or next to a Side required, if a Side be required.

By this Rule the Perpendicular muſt fall from the Angle X upon the Baſe ZY continued to W, and then in the Right-angled Triangle YWX, there is given the Side PY, and the Angle XYW (being the Complement

of the given Angle XYZ to 180 Degrees to find the Leg WY by Caſe I. of Right-angled Spherical Triangles, and adding WY to YZ the Sum is WZ, then by Concluſion the ſecond:

As *S.* WZ to *T.* XYW, ſo *S.* WY to *T.* XZW.

CASE VIII. *Fig.* 106.

Two Sides and an Angle included being given, to find the third Side.

Given { The Side XY, The Side YZ, The Angle XYZ } Required the Side XZ.

In this Caſe the Perpendicular falls from the Angles X by Sol. 8. and falls without upon the Side ZY continued to W by Sol. 9. for the ſame Reaſons as in Caſe VII. or it might be let fall from the Angle Z upon the Side XW continued, but we ſhall chuſe the former, *viz.* to let it fall from the Angle X to the Side ZY continued to W, then as in Caſe 7. Of Oblique Spherical Triangles you have given Angle WYZ, and the Hypotenuſe YX to find WY by Caſe I. of Right-angled Spherical Triangles, then adding WY to the given Side YZ, gives the whole Baſe WY, then find the required Side YZ by Concluſion the third:

As *S. C.* WY to *S. C.* XY, ſo *S. C.* WZ to *S. C.* XZ.

CASE IX. *Fig.* 107.

Two Angles and a Side included being given, to find either of the other Sides.

Given { The Angle B, The Angle G, The Side BG } Required the Side GN.

In this Caſe the Perpendicular falls from the Angle G upon the Side BN by Sol. 8, and falls within by Sol. 9.

and

and the Directions in Caſe VII. and then in the Triangle BGP, there is given the Side BG, and the Angle B, to find the Angle BGP by Caſe III. which Angle being found, ſubtract it from the whole Angle BGN, the Remainder is the Vertical Angle PGN, then by Concluſion the fourth:

As *S. C.* PGN to *T.* BG, ſo *S. C.* BGP to *T.* GN, which is the Side required.

CASE X. *Fig.* 108.

Two Angles and a Side comprehended being given, to find the other Angle.

Given { The Angle B, The Angle G, The Side B G } Required the Angle N.

Here by Sol. 8. and the Reaſons given in Caſe IX. the Perpendicular falls from the Angle G upon the Side BN, then in the Triangles BPG, there is given the Angle B, and the Side BG to find the Vertical Angle BGP by Caſe III. which being found and ſubtracted from the whole Vertical Angle PGN, there remains the Vertical Angle PGN, then find the required Angle PNG, by Concluſion the firſt, thus:

As *S.* BGP to *S. C.* GBP, ſo is *S.* PGN to *S. C.* PNG.

CASE XI. *Fig.* 109.

Three Sides given to find an Angle.

Given { The Side BG, The Side GN, The Side BN } Required the Angle GBN.

This Caſe may be performed by various Methods or by Concluſion 6, but being the required Angle is one of the Angles at the Baſe, it may be more commodiouſly done by Concluſion the ſixth, that is, As Tangent of half the Baſe

Baſe BN to Tangent of half the Sum of the Sides BG and GN, ſo Tangent of half the Difference of the ſaid Side, to Tangent of half the Difference of the Segments of the Baſe.

Then in the Triangle BPG there is given the Hypotenuſe BG, and Leg BP, to find the Angle required by Caſe IV. of Right-angled Spherical Triangles, *viz.*

As Rad. to *T.* BP, ſo *T. C.* BG, to *S. G.* PBG, the Angle required.

Note; When the greateſt Angle is required it is better to work it by Concluſion the ſixth.

CASE XII. *Fig.* 110.

Given three Angles to find a Side.

Take the Complement of the greateſt Angle to 180 Degrees, and then the Angles will be turned into Sides, and are to be calculated in all Reſpects as in Caſe the Eleventh, which we ſhall not need to repeat here, but ſhall be more large when we come to the Application to Aſtronomy.

SECT.

SECT. IV.

The Demonſtration of the firſt Five of the Concluſions, by which Oblique Spherical Triangles are ſolved by the Help of a Perpendicular.

OBſerve in all Spherical Triangles which require a Perpendicular to be let fall according to Sol. 8. the Perpendicular divides the Oblique Triangle in two Right-angled ones, and is common to both, if both the Angles at the Baſe be accute; for then it falls within by Sol. 9, or if it falls without, the Rules are evidently the ſame if we look upon the Oblique Triangles to be folded in the Perpendicular, and the leſſer unfolded out of the greater, the ſame Perpendicular is common to both, and the Demonſtration is the ſame.

The Demonſtration is deduced from the Fundamental Proportion by Sol. 4. provided we make Radius, and the Perpendicular which is common to both Triangles, the two firſt Terms in both Proportions; for they being deſtroyed, the two laſt Terms in both bear the ſame Proportion to each other, as the firſt and laſt in each did, as for *Example.*

Concluſion I. The Co-ſines of the Angles at the Baſe are directly proportionable to the Sines of the vertical Angles.

In the Triangles LNM let fall the Perpendicular NP by Sol. 8. and the Oblique Triangle LNM will be divided into two Right-angled ones LNP and MNP: Then becauſe the Proportion between the Angles at the Baſe, and the vertical Angles is the Thing ſought, and the Perpendicular NP and Radius muſt be the two firſt Terms; therefore in the Triangle LNP, the Angles L and N, and the Side NP, are concerned as Data and Queſita in the Triangle, and by the ſame Rule in the Triangle MNP the Angles M and N, and Side NP are to be made uſe of, then by Caſe 8, of Right-angled Spherical Triangles. *Fig.* 104.

In

In the Triangle { LNP: As *Rad.* to *S. C.* NP, ſo *S.* LNP to *S. C.* L. / MNP: As *Rad.* to *S. C.* NP, ſo *S.* MNP to *S. C.* M.

Deſtroy the two firſt Terms in each, it will be:

As *S.* LNP to *S. C.* L, ſo *S.* MNP to *S. C.* M.

That is, as Sine of one Vertical Angle to *S. C.* of its Angle at the Baſe, ſo Sine of the other Vertical Angle to *S. C.* of its Angle at the Baſe. *Which was to be proved.*

Concluſion II. The Sines of the Baſes are reciprocally proportional to the Tangent of the Angles at the Baſe.

Fig. 104. In the Triangle LNM, let fall the Perpendicular NP by Sol. 8. and then by the Directions above, the Baſes and the Angles at the Baſe are the Parts concerned in the Queſtion, to make (with Radius and the common Perpendicular) the four Terms in the Queſtion, and then by Caſe X. of Right-angled Spherical Triangles, it is:

In the Triangle { LNP: As *Rad.* to *T.* NP, ſo *T. C.* L to *S.* LP. / MNP: As *Rad.* to *T.* NP, ſo *T. C.* M to *S.* MP.

Deſtroy the two firſt Terms in each (being both the ſame) it will be:

As *T. C.* L to *S.* LP, ſo *T. C.* M to *S.* MP.

Alternately, as *T. C.* L to *T. C.* M, ſo *S.* LP to *S.* MP; but as *T. C.* of any Arch to *T. C.* of any other Arch, ſo *T.* of the latter the *T.* of the former (*Supplement to* Barrow's *Euclid.*) therefore;

As

As *T.* M to *S.* LP, ſo *T.* L to *S.* MP.

Concluſion the third. The Co-ſines of the Segment of the Baſe are directly proportional to the Co-ſines of the Hypotenuſes.

In the Triangle LNM let fall the Perpendicular NP to divide into two Right-angled ones LNP and MNP by Sol. 8. then as the Baſes and Hypotenuſes are the Parts concerned with Radius and the common Perpendicular NP, it will be by Caſe the XIV. *Fig.* 104.

In the Triangle { LNP: As *Rad.* to *S. C.* NP, ſo *S. C.* LP to *S. C.* LN
MNP: As *Rad.* to *S. C.* NP, ſo *S. C.* MP to *S. C.* MN

Deſtroy the two firſt Terms in each, it is:

As *S. C.* LP to *S. C.* LN, ſo *S. C.* MP to *S. C.* MN.

Concluſion the fourth. The Tangent of the Sides are reciprocally proportional to the Co-ſines of the Vertical Angles.

Let fall the Perpendicular NP as before, and then in the Triangle LNP the Side LN, and Angle N, and in the Triangle MNP, the Side MN, and the Angle N are the Parts concerned with Radius and the common Perpendicular NP, and by Caſe the IVth, it is: *Fig.* 104.

In the Triangle { LNP: As *Rad.* to *T.* NP, ſo *T. C.* LN to *S. C.* N.
MNP: As *Rad.* to *T.* NP, ſo *T. C.* MN to *S. C.* N.

Deſtroy the two firſt Terms in each, it is:

As *T. C.* LN to *S. C.* LNP, ſo *T. C.* MN to *S. C.* MNP, or by mutually changing Tang. Comp. for Tangent, is *T.* MN to *S. C.* LNP, ſo *T.* LN to *S. C.* MNP.

Concluſion the fifth. The Tangents of the Baſes are directly proportional to the Tangents of the Vertical Angles.

In

In the Oblique Triangle LNM divided into two Right-angled ones by the Perpendicular NP, as before, the Parts concerned are the Baſes and Vertical Angle, *viz.* in the Triangle LPN, the Angle LNP, and Sides LP and NP, and in the Triangle MPN, the Angle MNP, and the Sides PM and PN, but becauſe PN is middle Part, it cannot come in with Radius to poſſeſs the firſt and ſecond Places in the Proportion, without Tranſpoſition or Alteration, which may be thus done.—— Firſt, by Caſe the Tenth. *Fig.* 104.

In the Triangle { LPN: As *Rad.* to *T.* LP, ſo *T. C.* LNP to *S.* NP. MNP: As *Rad.* to *T.* PM, ſo *T. C.* MNP to *S.* NP.

Therefore *(by Supplement to Barrow's Euclide.)*

In the Triangle { LNP: As *T. C.* PL to *Rad.* ſo *T. C.* LNP to *S.* NP. MPN: As *T. C.* PM to *Rad.* ſo *T. C.* MNP to *S.* NP.

By Permutation, *Euclide Lib.* 5. *Def.* 12.

In the Triangle { LPN; As *T. C.* LP to *T. C.* LNP, ſo *Rad.* to *S.* NP. MNP; As *T. C.* PM to *T. C.* MNP, ſo *Rad.* to *S.* NP.

Deſtroy the two laſt Terms being both the ſame in each, and the remaining Proportion will be:

As *T. C.* LP to *T. C.* LNP, ſo *T. C.* PM to *T. C.* MNP.

But as the Tangent Complement of any Arch is to the Tangent Complement of any other Arch, ſo the Tangent of the latter Arch to the Tangent of the former, (becauſe every Tangent multiplied by its Complement produceth the Square of Radius) therefore it is:

As *T. C.* LP to *T. C.* LNP, ſo *T.* LNP to *T.* LP.

And for the ſame Reaſon:

As *T. C.* PM to *T. C.* MNP, ſo *T.* MNP to *T.* PM.

There

Therefore in an inverſe Proportion:

As *T.* LNP to *T.* LP, ſo *T.* MNP to *T.* MP.

That is, as the Tangent of one Segment of the Baſe to the Tangent of its Vertical Angle, ſo the Tangent of the other Segment of the Baſe to the Tangent of the Vertical Angle. *Which was to be demonſtrated.*

Theſe Concluſions are ſufficient in all Caſes of Oblique Spherical Triangles, and I thought it more proper to demonſtrate them here, than to interrupt the Learner with a Demonſtration in the Practice of the 28 Caſes of Spherical Triangles.

Of Quadrantal Triangles.

As Right-angled Triangles are ſo called, becauſe they have one Angle, that is a Quadrant or 90 Degrees; ſo the Quadrantal ones take that Name from their having one Side a Quadrant or 90 Degrees, as in the Triangle A ⊙ P, the Side A P being a Quadrant or 90 Degrees, or in Aſtronomical Terms (which we ſhall explain hereafter) the Side A ⊙ is the Sun's Longitude, the Side ⊙ P is the Complement of the Sun's Declination, and the Side A P is a Quadrant or the Poles Diſtance from the Equinoctial, *&c.* *Fig.* 65.

Theſe Quadrantal Triangles are ſolved by the ſame univerſal Proportion, as Right-angled ones are, if we uſe the Sides of the Quadrantals as we do the Angles of the Right-angled, *viz.* as in Right-angled Triangle, the Right Angle is excepted, and the other two Angles and the three Sides are called the five circular Parts, ſo in Quadrantal, the Quadrantal Side is excepted, and the other two Sides and the three Angles make the five circular Parts; but all the Parts whether Sides or Angles (except the Quadrantal Side) are called Conjuncts, Diſjuncts and Middle Part, as Right-angled Triangles are, and with the ſame Limitation, *viz.* that the two Angles next the Quadrantal Side, are called by their Complements, *viz.* if they are Conjuncts they are called Tangent Com-

Complements, and Sines if they are Disjuncts: and if Middle Part they are Sine Complements, and in all other Cases they are performed as in Solution 4, with the Caution in Solution 5 and 6, as one Example will sufficiently explain.

Fig. 65. Suppose in the Triangle A P ⊙ there is given its Sides A ⊙ and ⊙ P, to find an Angle at ⊙, here A ⊙ and ⊙ P are Conjuncts, and the Angle ⊙ is Middle Part, and because the Parts given and required are remote from the Quadrantal Side, they are called by their Complements; and hence the Proportion is:

As Rad to *T. C.* A ⊙, so *T. C.* ⊙ P to *S. C.* A ⊙ P.

It will be needless to repeat any more Examples, it being scarce possible, after their Directions, for any that understands Right-angled Spherical Triangles, to mistake in solving the Quadrantal ones.

TABLE

OF

DIFFERENCE

OF

Latitude and *Departure*

IN

MINUTES and TENTH PARTS,

to every *Degree* and *Quarter-Point*

OF THE

COMPASS,

For the exact working of a

TRAVERSE,

And readily finding the

LONGITUDE

BY

INSPECTION,

According to Middle Latitude.

Dist.	1 Deg.		2 Deg.		¼ Point		3 Deg.		4 Deg.		5 Deg.		Dist.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	01.0	00.0	01.0	00.0	01.0	00.0	01.0	00.1	01.0	00.1	01.0	00.1	1
2	02.0	00.1	02.0	00.1	02.0	00.1	02.0	00.1	02.0	00.1	02.0	00.2	2
3	03.0	00.1	03.0	00.1	03.0	00.1	03.0	00.2	03.0	00.2	03.0	00.3	3
4	04.0	00.1	04.0	00.1	04.0	00.2	04.0	00.2	04.0	00.3	04.0	00.3	4
5	05.0	00.1	05.0	00.2	05.0	00.2	05.0	00.3	05.0	00.3	05.0	00.4	5
6	06.0	00.1	06.0	00.2	06.0	00.3	06.0	00.3	06.0	00.4	06.0	00.5	6
7	07.0	00.1	07.0	00.2	07.0	00.3	07.0	00.4	07.0	00.5	07.0	00.6	7
8	08.0	00.1	08.0	00.3	08.0	00.4	08.0	00.4	08.0	00.6	08.0	00.7	8
9	09.0	00.2	09.0	00.3	09.0	00.4	09.0	00.5	09.0	00.6	09.0	00.8	9
10	10.0	00.2	10.0	00.4	10.0	00.5	10.0	00.5	10.0	00.7	10.0	00.9	10
11	11.0	00.2	11.0	00.4	11.0	00.5	11.0	00.6	11.0	00.8	11.0	01.0	11
12	12.0	00.2	12.0	00.4	12.0	00.6	12.0	00.6	12.0	00.8	12.0	01.0	12
13	13.0	00.2	13.0	00.5	13.0	00.6	13.0	00.7	13.0	00.9	12.9	01.1	13
14	14.0	00.2	14.0	00.5	14.0	00.7	14.0	00.7	14.0	01.0	13.9	01.2	14
15	15.0	00.3	15.0	00.5	15.0	00.7	15.0	00.8	15.0	01.0	14.9	01.3	15
16	16.0	00.3	16.0	00.6	16.0	00.8	16.0	00.8	16.0	01.1	15.9	01.4	16
17	17.0	00.3	17.0	00.6	17.0	00.8	17.0	00.9	17.0	01.2	16.9	01.5	17
18	18.0	00.3	18.0	00.6	18.0	00.9	18.0	00.9	18.0	01.3	17.9	01.6	18
19	19.0	00.3	19.0	00.7	19.0	00.9	19.0	01.0	19.0	01.3	18.9	01.7	19
20	20.0	00.4	20.0	00.7	20.0	01.0	20.0	01.0	20.0	01.4	19.9	01.7	20
21	21.0	00.4	21.0	00.7	21.0	01.0	21.0	01.1	20.9	01.5	20.9	01.8	21
22	22.0	00.4	22.0	00.8	22.0	01.1	22.0	01.1	21.9	01.5	21.9	01.9	22
23	23.0	00.4	23.0	00.8	23.0	01.1	23.0	01.2	22.9	01.6	22.9	02.0	23
24	24.0	00.4	24.0	00.8	24.0	01.2	24.0	01.3	23.9	01.7	23.9	02.1	24
25	25.0	00.4	25.0	00.9	25.0	01.2	25.0	01.3	24.9	01.7	24.9	02.2	25
26	26.0	00.5	26.0	00.9	26.0	01.3	26.0	01.4	25.9	01.8	25.9	02.3	26
27	27.0	00.5	27.0	00.9	27.0	01.3	27.0	01.4	26.9	01.9	26.9	02.4	27
28	28.0	00.5	28.0	01.0	28.0	01.4	28.0	01.5	27.9	02.0	27.9	02.4	28
29	29.0	00.5	29.0	01.0	29.0	01.4	29.0	01.5	28.9	02.0	28.9	02.5	29
30	30.0	00.5	30.0	01.1	30.0	01.5	30.0	01.6	29.9	02.1	29.9	02.6	30
31	31.0	00.5	31.0	01.1	31.0	01.5	31.0	01.6	30.9	02.2	30.9	02.7	31
32	32.0	00.6	32.0	01.1	32.0	01.6	32.0	01.7	31.9	02.2	31.9	02.8	32
33	33.0	00.6	33.0	01.2	33.0	01.6	33.0	01.7	32.9	02.3	32.9	02.9	33
34	34.0	00.6	34.0	01.2	34.0	01.7	34.0	01.8	33.9	02.4	33.9	03.0	34
35	35.0	00.6	35.0	01.2	35.0	01.7	35.0	01.8	34.9	02.4	34.9	03.1	35
36	36.0	00.6	36.0	01.3	36.0	01.8	35.9	01.9	35.9	02.5	35.9	03.1	36
37	37.0	00.6	37.0	01.3	37.0	01.8	36.9	01.9	36.9	02.6	36.9	03.2	37
38	38.0	00.7	38.0	01.3	38.0	01.9	37.9	02.0	37.9	02.7	37.9	03.3	38
39	39.0	00.7	39.0	01.4	39.0	01.9	38.9	02.0	38.9	02.7	38.9	03.4	39
40	40.0	00.7	40.0	01.4	40.0	02.0	39.9	02.1	39.9	02.8	39.8	03.5	40
41	41.0	00.7	41.0	01.4	41.0	02.0	40.9	02.1	40.9	02.9	40.8	03.6	41
42	42.0	00.7	42.0	01.5	41.9	02.1	41.9	02.2	41.9	02.9	41.8	03.7	42
43	43.0	00.8	43.0	01.5	42.9	02.1	42.9	02.2	42.9	03.0	42.8	03.8	43
44	44.0	00.8	44.0	01.5	43.9	02.2	43.9	02.3	43.9	03.1	43.8	03.8	44
45	45.0	00.8	45.0	01.6	44.9	02.2	44.9	02.4	44.9	03.1	44.8	03.9	45
46	46.0	00.8	46.0	01.6	45.9	02.3	45.9	02.4	45.9	03.2	45.8	04.0	46
47	47.0	00.8	47.0	01.6	46.9	02.3	46.9	02.5	46.9	03.3	46.8	04.1	47
48	48.0	00.8	48.0	01.7	47.9	02.4	47.9	02.5	47.9	03.4	47.8	04.2	48
49	49.0	00.9	49.0	01.7	48.9	02.4	48.9	02.6	48.9	03.4	48.8	04.3	49
50	50.0	00.9	50.0	01.7	49.9	02.5	49.9	02.6	49.9	03.5	49.8	04.4	50
Dist.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist.
	89 Deg.		88 Deg.		7½ Point		87 Deg.		86 Deg.		85 Deg.		

Dist	1 Deg.		2 Deg.		¼ Point		3 Deg.		4 Deg.		5 Deg.		Dist
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	51.0	00.9	51.0	01.8	50.9	02.5	50.9	02.7	50.9	03.6	50.8	04.4	51
52	52.0	00.9	52.0	01.8	51.9	02.6	51.9	02.7	51.9	03.6	51.8	04.5	52
53	53.0	00.9	53.0	01.8	52.9	02.6	52.9	02.8	52.9	03.7	52.8	04.6	53
54	54.0	00.9	54.0	01.9	53.9	02.7	53.9	02.8	53.9	03.8	53.8	04.7	54
55	55.0	01.0	55.0	01.9	54.9	02.7	54.9	02.8	54.9	03.8	54.8	04.8	55
56	56.0	01.0	56.0	02.0	55.9	02.7	55.9	02.9	55.9	03.9	55.8	04.9	56
57	57.0	01.0	57.0	02.0	56.9	02.8	56.9	03.0	56.9	04.0	56.8	05.0	57
58	58.0	01.0	58.0	02.0	57.9	02.8	57.9	03.0	57.9	04.0	57.8	05.1	58
59	59.0	01.0	59.0	02.1	58.9	02.9	58.9	03.1	58.9	04.1	58.8	05.1	59
60	60.0	01.1	60.0	02.1	59.9	02.9	59.9	03.1	59.9	04.2	59.8	05.2	60
61	61.0	01.1	61.0	02.1	60.9	03.0	60.9	03.2	60.9	04.3	60.8	05.3	61
62	62.0	01.1	62.0	02.2	61.9	03.0	61.9	03.2	61.9	04.3	61.8	05.4	62
63	63.0	01.1	63.0	02.2	62.9	03.1	62.9	03.3	62.8	04.4	62.8	05.5	63
64	64.0	01.1	64.0	02.2	63.9	03.1	63.9	03.3	63.8	04.5	63.8	05.6	64
65	65.0	01.1	65.0	02.3	64.9	03.2	64.9	03.4	64.8	04.5	64.8	05.7	65
66	66.0	01.2	66.0	02.3	65.9	03.2	65.9	03.5	65.8	04.6	65.7	05.8	66
67	67.0	01.2	67.0	02.3	66.9	03.3	66.9	03.5	66.8	04.7	66.7	05.8	67
68	68.0	01.2	68.0	02.4	67.9	03.3	67.9	03.6	67.8	04.7	67.7	05.9	68
69	69.0	01.2	69.0	02.4	68.9	03.4	68.9	03.6	68.8	04.8	68.7	06.0	69
70	70.0	01.2	70.0	02.4	69.9	03.4	69.9	03.7	69.8	04.9	69.7	06.1	70
71	71.0	01.2	71.0	02.5	70.9	03.5	70.9	03.7	70.8	05.0	70.7	06.2	71
72	72.0	01.3	72.0	02.5	71.9	03.5	71.9	03.8	71.8	05.0	71.7	06.3	72
73	73.0	01.3	73.0	02.5	72.9	03.6	72.9	03.8	72.8	05.1	72.7	06.4	73
74	74.0	01.3	74.0	02.6	73.9	03.6	73.9	03.9	73.8	05.2	73.7	06.5	74
75	75.0	01.3	75.0	02.6	74.9	03.7	74.9	03.9	74.8	05.2	74.7	06.5	75
76	76.0	01.3	76.0	02.7	75.9	03.7	75.9	04.0	75.8	05.3	75.7	06.6	76
77	77.0	01.3	77.0	02.7	76.9	03.8	76.9	04.0	76.8	05.4	76.7	06.7	77
78	78.0	01.4	78.0	02.7	77.9	03.8	77.9	04.1	77.8	05.5	77.7	06.8	78
79	79.0	01.4	79.0	02.8	78.9	03.9	78.9	04.1	78.8	05.5	78.7	06.9	79
80	80.0	01.4	80.0	02.8	79.9	03.9	79.9	04.2	79.8	05.6	79.7	07.0	80
81	81.0	01.4	81.0	02.8	80.9	04.0	80.9	04.2	80.8	05.7	80.7	07.1	81
82	82.0	01.4	81.9	02.9	81.9	04.0	81.9	04.3	81.8	05.7	81.7	07.2	82
83	83.0	01.5	82.9	02.9	82.9	04.1	82.9	04.3	82.8	05.8	82.7	07.2	83
84	84.0	01.5	83.9	02.9	83.9	04.1	83.9	04.4	83.8	05.9	83.7	07.3	84
85	85.0	01.5	84.9	03.0	84.9	04.2	84.9	04.4	84.8	05.9	84.7	07.4	85
86	86.0	01.5	85.9	03.0	85.9	04.2	85.9	04.5	85.8	06.0	85.7	07.5	86
87	87.0	01.5	86.9	03.0	86.9	04.3	86.9	04.6	86.8	06.1	86.7	07.6	87
88	88.0	01.5	87.9	03.1	87.9	04.3	87.9	04.6	87.8	06.1	87.7	07.7	88
89	89.0	01.6	88.9	03.1	88.9	04.4	88.9	04.7	88.8	06.2	88.7	07.8	89
90	90.0	01.6	89.9	03.1	89.9	04.4	89.9	04.7	89.8	06.3	89.7	07.8	90
91	91.0	01.6	90.9	03.2	90.9	04.5	90.9	04.8	95.8	06.4	90.7	07.9	91
92	92.0	01.6	91.9	03.2	91.9	04.5	91.9	04.8	91.8	06.4	91.6	08.0	92
93	93.0	01.6	92.9	03.2	92.9	04.6	92.9	04.9	92.8	06.5	92.6	08.1	93
94	94.0	01.6	93.9	03.3	93.9	04.6	93.9	04.9	93.8	06.6	93.6	08.2	94
95	95.0	01.7	94.9	03.3	94.9	04.7	94.9	05.0	94.8	06.6	94.6	08.3	95
96	96.0	01.7	95.9	03.4	95.9	04.7	95.9	05.0	95.8	06.7	95.6	08.4	96
97	97.0	01.7	96.9	03.4	96.9	04.8	96.9	05.1	96.8	06.8	96.6	08.5	97
98	98.0	01.7	97.9	03.4	97.9	04.8	97.9	05.1	97.8	06.8	97.6	08.5	98
99	99.0	01.7	98.9	03.5	98.9	04.9	98.9	05.2	98.8	06.9	98.6	08.6	99
100	100.0	01.7	99.9	03.5	99.9	04.9	99.9	05.2	99.8	07.0	99.6	08.7	100
Dist	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist
	89 Deg.		88 Deg.		7¼ Point		87 Deg.		86 Deg.		85 Deg.		

Diff	¼ Point		6 Deg.		7 Deg.		8 Deg.		¼ Point		9 Deg.		Diff
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.1	01.0	00.2	1
2	02.0	00.2	02.0	00.2	02.0	00.2	02.0	00.3	02.0	00.3	02.0	00.3	2
3	03.0	00.3	03.0	00.3	03.0	00.4	03.0	00.4	03.0	00.4	03.0	00.5	3
4	04.0	00.4	04.0	00.4	04.0	00.5	04.0	00.6	04.0	00.6	03.9	00.6	4
5	05.0	00.5	05.0	00.5	05.0	00.6	05.0	00.7	04.9	00.7	04.9	00.8	5
6	06.0	00.6	06.0	00.6	06.0	00.7	05.9	00.8	05.9	00.9	05.9	00.9	6
7	07.0	00.7	07.0	00.7	06.9	00.9	06.9	01.0	06.9	01.0	06.9	01.1	7
8	08.0	00.8	08.0	00.8	07.9	01.0	07.9	01.1	07.9	01.2	07.9	01.3	8
9	09.0	00.9	08.9	00.9	08.9	01.1	08.9	01.2	08.9	01.3	08.9	01.4	9
10	10.0	01.0	09.9	01.0	09.9	01.2	09.9	01.4	09.9	01.5	09.9	01.6	10
11	10.9	01.1	10.9	01.1	10.9	01.3	10.9	01.5	10.9	01.6	10.9	01.7	11
12	11.9	01.2	11.9	01.3	11.9	01.5	11.9	01.7	11.9	01.8	11.9	01.9	12
13	12.9	01.3	12.9	01.4	12.9	01.6	12.9	01.8	12.9	01.9	12.8	02.0	13
14	13.9	01.4	13.9	01.5	13.9	01.7	13.9	01.9	13.8	02.1	13.8	02.2	14
15	14.9	01.5	14.9	01.6	14.9	01.8	14.9	02.1	14.8	02.2	14.8	02.3	15
16	15.9	01.6	15.9	01.7	15.9	01.9	15.8	02.2	15.8	02.3	15.8	02.5	16
17	16.9	01.7	16.9	01.8	16.9	02.1	16.8	02.4	16.8	02.5	16.8	02.7	17
18	17.9	01.8	17.9	01.9	17.9	02.2	17.8	02.5	17.8	02.6	17.8	02.8	18
19	18.9	01.9	18.9	02.0	18.9	02.3	18.8	02.6	18.8	02.8	18.8	03.0	19
20	19.9	02.0	19.9	02.1	19.8	02.4	19.8	02.8	19.8	02.9	19.8	03.1	20
21	20.9	02.1	20.9	02.2	20.8	02.6	20.8	02.9	20.8	03.1	20.7	03.3	21
22	21.9	02.2	21.9	02.3	21.8	02.7	21.8	03.1	21.8	03.2	21.7	03.4	22
23	22.9	02.3	22.9	02.4	22.8	02.8	22.8	03.2	22.8	03.4	22.7	03.6	23
24	23.9	02.4	23.9	02.5	23.8	02.9	23.8	03.3	23.7	03.5	23.7	03.8	24
25	24.9	02.4	24.9	02.6	24.8	03.0	24.8	03.5	24.7	03.7	24.7	03.9	25
26	25.9	02.5	25.9	02.7	25.8	03.2	25.7	03.6	25.7	03.8	25.7	04.1	26
27	26.9	02.6	26.9	02.8	26.8	03.3	26.7	03.8	26.7	04.0	26.7	04.2	27
28	27.9	02.7	27.8	02.9	27.8	03.4	27.7	03.9	27.7	04.1	27.7	04.4	28
29	28.9	02.8	28.8	03.0	28.8	03.5	28.7	04.0	28.7	04.3	28.6	04.5	29
30	29.9	02.9	29.8	03.1	29.8	03.7	29.7	04.2	29.7	04.4	29.6	04.7	30
31	30.8	03.0	30.8	03.2	30.8	03.8	30.7	04.3	30.7	04.5	30.6	04.9	31
32	31.8	03.1	31.8	03.3	31.8	03.9	31.7	04.5	31.7	04.7	31.6	05.1	32
33	32.8	03.2	32.8	03.4	32.8	04.0	32.7	04.6	32.6	04.8	32.6	05.2	33
34	33.8	03.3	33.8	03.6	33.7	04.1	33.7	04.7	33.6	05.0	33.6	05.4	34
35	34.8	03.4	34.8	03.7	34.7	04.3	34.7	04.9	34.6	05.1	34.6	05.5	35
36	35.8	03.5	35.8	03.8	35.7	04.4	35.6	05.0	35.6	05.3	35.6	05.6	36
37	36.8	03.6	36.8	03.9	36.7	04.5	36.6	05.1	36.6	05.4	36.5	05.8	37
38	37.8	03.7	37.8	04.0	37.7	04.6	37.6	05.3	37.6	05.6	37.5	05.9	38
39	38.8	03.8	38.8	04.1	38.7	04.8	38.6	05.4	38.6	05.7	38.5	06.1	39
40	39.8	03.9	39.8	04.2	39.7	04.9	39.6	05.6	39.6	05.9	39.5	06.3	40
41	40.8	04.0	40.8	04.3	40.7	05.0	40.6	05.7	40.6	06.0	40.5	06.4	41
42	41.8	04.1	41.8	04.4	41.7	05.1	41.6	05.8	41.5	06.2	41.5	06.6	42
43	42.8	04.2	42.8	04.5	42.7	05.2	42.6	06.0	42.5	06.3	42.5	06.7	43
44	43.8	04.3	43.8	04.6	43.7	05.4	43.6	06.1	43.5	06.5	43.5	06.9	44
45	44.8	04.4	44.8	04.7	44.7	05.5	44.6	06.3	44.5	06.6	44.4	07.0	45
46	45.8	04.5	45.7	04.8	45.7	05.6	45.6	06.4	45.5	06.7	45.4	07.2	46
47	46.8	04.6	46.7	04.9	46.6	05.7	46.5	06.6	46.5	06.9	46.4	07.3	47
48	47.8	04.7	47.7	05.0	47.6	05.9	47.5	06.7	47.3	07.0	47.4	07.5	48
49	48.8	04.8	48.7	05.1	48.6	06.0	48.5	06.8	48.5	07.2	48.4	07.7	49
50	49.8	04.9	49.7	05.2	49.6	06.1	49.5	07.0	49.5	07.3	49.4	07.8	50
Diff	Dep	Lat	Dep	Dep	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Diff
	7¼ Points		84 Deg.		83 Deg.		82 Deg.		7¼ Point		81 Deg.		

Dist	¼ Point		6 Deg.		7 Deg.		8 Deg.		¼ Point		9 Deg.		Dist
	Lat	Lat	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	50.8	05.0	50.7	05.3	50.6	06.2	50.5	07.1	50.4	07.5	50.4	08.0	5
52	51.7	05.1	51.7	05.4	51.6	06.3	51.5	07.2	51.4	07.6	51.4	08.1	52
53	52.7	05.2	52.7	05.5	52.6	06.5	52.5	07.4	52.4	07.8	52.3	08.3	53
54	53.7	05.3	53.7	05.6	53.6	06.6	53.5	07.5	53.4	07.9	53.3	08.4	54
55	54.7	05.4	54.7	05.7	54.6	06.7	54.5	07.7	54.4	08.1	54.3	08.6	55
56	55.7	05.5	55.7	05.9	55.6	06.8	55.5	07.8	55.4	03.2	55.3	08.8	56
57	56.7	05.6	56.7	06.0	56.6	06.9	56.4	07.9	56.4	08.4	56.3	08.9	57
58	57.7	05.7	57.7	06.1	57.6	07.1	57.4	08.1	57.4	08.5	57.3	09.1	58
59	58.7	05.8	58.7	06.2	58.6	07.2	58.4	08.2	58.4	08.7	58.3	09.2	59
60	59.7	05.9	59.7	06.3	59.5	07.3	59.4	08.4	59.4	08.8	59.3	09.4	60
61	60.7	06.0	60.7	06.4	60.5	07.4	60.4	08.5	60.3	08.9	60.2	09.5	61
62	61.7	06.1	61.7	06.5	61.5	07.6	61.4	08.6	61.3	09.1	61.2	09.7	62
63	62.7	06.2	62.7	06.6	62.5	07.7	62.4	08.8	62.3	09.2	62.2	09.9	63
64	63.7	06.3	63.6	06.7	63.5	07.8	63.4	58.9	63.3	09.4	63.2	10.0	64
65	64.7	06.4	64.6	06.8	64.5	07.9	64.4	09.0	64.3	09.5	64.2	10.2	65
66	65.7	06.5	65.6	06.9	65.5	08.0	65.4	09.2	65.3	09.7	65.2	10.3	66
67	66.7	06.6	66.6	07.0	66.5	08.2	66.3	09.3	66.3	09.8	66.2	10.5	67
68	67.7	06.7	67.6	07.1	67.5	08.3	67.3	09.5	67.3	10.0	67.2	10.6	68
69	68.7	06.8	68.6	07.2	68.5	08.4	68.3	09.6	68.3	10.1	68.2	10.8	69
70	69.7	06.9	69.6	07.3	69.5	08.5	69.3	09.7	69.2	10.3	69.1	10.9	70
71	70.7	07.0	70.6	07.4	70.5	08.7	70.3	09.9	70.2	10.4	70.1	11.1	71
72	71.7	07.1	71.6	07.5	71.5	08.8	71.3	10.0	71.2	10.6	71.1	11.3	72
73	72.6	07.2	72.6	07.6	72.5	08.9	72.3	10.2	72.2	10.7	72.1	11.4	73
74	73.6	07.3	73.6	07.7	73.4	09.0	73.3	10.3	73.2	10.9	73.1	11.6	74
75	74.6	07.3	74.6	07.8	74.4	09.1	74.3	10.4	74.2	11.0	74.1	11.7	75
76	75.6	07.4	75.6	07.9	75.4	09.3	75.3	10.6	75.2	11.1	75.1	11.9	76
77	76.6	07.5	76.6	08.0	76.4	09.4	76.3	10.7	76.2	11.3	76.1	12.0	77
78	77.6	07.6	77.6	08.1	77.4	09.5	77.2	10.9	77.2	11.4	77.0	12.2	78
79	78.6	07.7	78.6	08.3	78.4	09.6	78.2	11.0	78.1	11.6	78.0	12.4	79
80	79.6	07.8	79.6	08.4	79.4	09.8	79.2	11.1	79.1	11.7	79.0	12.5	80
81	80.6	07.9	80.6	08.5	80.4	09.9	80.2	11.3	80.1	11.9	80.0	12.7	81
82	81.6	08.0	81.5	08.6	81.4	10.0	81.2	11.4	81.1	12.0	81.0	12.8	82
83	82.6	08.1	82.5	08.7	82.4	10.1	82.2	11.6	82.1	12.2	82.0	13.0	83
84	83.6	08.2	83.5	08.8	83.4	10.2	83.2	11.7	83.1	12.3	83.0	13.1	84
85	84.6	08.3	84.5	08.9	84.4	10.4	84.2	11.8	84.1	12.5	84.0	13.3	85
86	85.6	08.4	85.5	09.0	85.4	10.5	85.2	12.0	85.1	12.6	84.9	13.4	80
87	86.6	08.5	86.5	09.1	86.3	10.6	86.2	12.1	86.0	12.8	85.9	13.6	87
88	87.6	08.6	87.5	09.2	87.3	10.7	87.1	12.2	87.0	12.9	86.9	13.8	88
89	88.6	08.7	88.5	09.3	88.3	10.8	88.1	12.4	88.0	13.1	87.9	13.9	89
90	89.6	08.8	89.5	09.4	89.3	11.0	89.1	12.5	89.0	13.2	88.9	14.1	90
91	90.6	08.9	90.5	09.5	90.3	11.1	90.1	12.7	90.0	13.3	89.9	14.2	91
92	91.6	09.0	91.5	09.6	91.3	11.2	91.1	12.8	91.0	13.5	90.9	14.4	92
93	92.6	09.1	92.5	09.7	92.3	11.3	92.1	12.9	92.0	13.6	91.9	14.5	93
94	93.5	09.2	93.5	09.8	93.3	11.5	93.1	13.1	93.0	13.8	92.8	14.7	94
95	94.5	09.3	94.5	09.9	94.3	11.6	94.1	13.2	94.0	13.9	93.8	14.9	95
96	95.3	09.4	95.5	10.0	95.3	11.7	95.1	13.4	95.0	14.1	94.8	15.0	96
97	96.5	09.5	96.5	10.1	96.3	11.8	96.1	13.5	96.0	14.2	95.8	15.2	97
98	97.5	09.6	97.5	10.2	97.3	11.9	97.0	13.6	96.9	14.4	96.8	15.3	98
99	98.5	09.7	98.5	10.3	98.3	12.1	98.0	13.8	97.9	14.5	97.8	15.5	99
100	99.5	09.8	99.4	10.4	99.2	12.2	99.0	13.9	98.9	14.7	98.8	15.6	100
Dist	Dep	Lat	Dep	Lat	Lat	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist
	7¼ Point		84 Deg.		83 Deg.		82 Deg.		7¼ Point		81 Deg.		

Dist	10 Deg.		11 Deg.		1 Point		12 Deg.		13 Deg.		14 Deg		Dist
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Deg	
1	01.0	00.2	01.0	00.2	01.0	00.2	01.0	00.2	01.0	00.2	01.0	00.2	1
2	02.0	00.3	02.0	00.4	02.0	00.4	02.0	00.4	01.9	00.4	01.9	00.5	2
3	03.0	00.5	02.9	00.6	02.9	00.6	02.9	00.6	02.9	00.7	02.9	00.7	3
4	03.9	00.7	03.9	00.8	03.9	00.8	03.9	00.8	03.9	00.9	03.9	01.0	4
5	04.9	00.9	04.9	01.0	04.9	01.0	04.9	01.0	04.9	01.1	04.9	01.2	5
6	05.9	01.0	05.9	01.1	05.9	01.2	05.9	01.2	05.8	01.3	05.8	01.4	6
7	06.9	01.2	06.9	01.3	06.9	01.4	06.8	01.5	06.8	01.6	06.8	01.7	7
8	07.9	01.4	07.9	01.5	07.8	01.6	07.8	01.7	07.8	01.8	07.8	01.9	8
9	08.9	01.6	08.8	01.7	08.8	01.8	08.8	01.9	08.8	02.0	08.7	02.2	9
10	09.8	01.7	09.8	01.9	09.8	02.0	09.8	02.1	09.7	02.2	09.7	02.4	10
11	10.8	01.9	10.8	02.1	10.8	02.1	10.8	02.3	10.7	02.5	10.7	02.7	11
12	11.8	02.1	11.8	02.3	11.8	02.3	11.7	02.5	11.7	02.7	11.6	02.9	12
13	12.8	02.3	12.8	02.5	12.7	02.5	12.7	02.7	12.7	02.9	12.6	03.1	13
14	13.8	02.4	13.7	02.7	13.7	02.7	13.7	02.9	13.6	03.1	13.6	03.4	14
15	14.8	02.6	14.7	02.9	14.7	02.9	14.7	03.1	14.6	03.4	14.6	03.6	15
16	15.8	02.8	15.7	03.1	15.7	03.1	15.6	03.3	15.6	03.6	15.5	03.9	16
17	16.7	03.0	16.7	03.2	16.7	03.3	16.6	03.5	16.6	03.8	16.5	04.1	17
18	17.7	03.1	17.7	03.4	17.7	03.5	17.6	07.7	17.5	04.0	17.5	04.4	18
19	18.7	03.3	18.6	03.6	18.6	03.7	18.6	03.9	18.5	04.3	18.4	04.6	19
20	19.7	03.5	19.6	03.8	19.6	03.9	19.6	04.1	19.5	04.5	19.4	04.8	20
21	20.7	03.6	20.6	04.0	20.6	04.1	20.5	04.4	20.5	04.7	20.4	05.1	21
22	21.7	03.8	21.6	04.2	21.6	04.3	21.5	04.6	21.4	04.9	21.3	05.3	22
23	22.6	04.0	22.6	04.4	22.6	04.5	22.5	04.8	22.4	05.2	22.3	05.6	23
24	23.6	04.2	23.6	04.6	23.5	04.7	23.5	05.0	23.4	05.4	23.3	05.8	24
25	24.6	04.3	24.5	04.8	24.5	04.9	24.5	05.2	24.4	05.6	24.3	06.0	25
26	25.6	04.5	25.5	05.0	25.5	05.1	25.4	05.4	25.3	05.8	25.2	06.3	26
27	26.6	04.7	26.5	05.2	26.5	05.3	26.4	05.6	26.3	06.1	26.2	06.5	27
28	27.6	04.9	27.5	05.3	27.5	05.5	27.4	05.8	27.3	06.3	27.2	06.8	28
29	28.6	05.0	28.5	05.5	28.4	05.7	28.4	06.0	28.3	06.5	28.1	07.0	29
30	29.5	05.2	29.4	05.7	29.4	05.9	29.3	06.2	29.2	06.7	29.1	07.3	30
31	30.5	05.4	30.4	05.9	30.4	06.0	30.3	06.4	30.2	07.0	30.1	07.5	31
32	31.5	05.6	31.4	06.1	31.4	06.2	31.3	06.7	31.2	07.2	31.0	07.7	32
33	32.5	05.7	32.4	06.3	32.4	06.4	32.3	06.9	32.2	07.4	32.0	08.0	33
34	33.5	05.9	33.4	06.5	33.3	06.6	33.3	07.1	33.1	07.6	33.0	08.2	34
35	34.5	06.1	34.4	06.7	34.3	06.8	34.2	07.3	34.1	07.9	34.0	08.5	35
36	35.4	06.2	35.3	06.9	35.3	07.0	35.2	07.5	35.1	08.1	34.9	08.7	36
37	36.4	06.4	36.3	07.1	36.3	07.2	36.2	07.7	36.1	08.3	35.9	09.0	37
38	37.4	06.6	37.3	07.2	37.3	07.4	37.2	07.9	37.0	08.5	36.9	09.2	38
39	38.4	06.8	38.3	07.4	38.3	07.6	38.1	08.1	38.0	08.8	37.8	09.4	39
40	39.4	06.9	39.3	07.6	39.2	07.8	39.1	08.3	39.0	09.0	38.8	09.7	40
41	40.4	07.1	40.2	07.8	40.2	08.0	40.1	08.5	39.9	09.2	39.8	09.9	41
42	41.4	07.3	41.2	08.0	41.2	08.2	41.1	08.7	40.9	09.4	40.8	10.2	42
43	42.3	07.5	42.2	08.2	42.2	08.4	42.1	08.9	41.9	09.7	41.7	10.4	43
44	43.3	07.6	43.2	08.4	43.2	08.6	43.0	09.1	42.9	09.9	42.7	10.6	44
45	44.3	07.8	44.2	08.6	44.1	08.8	44.0	09.4	43.8	10.1	43.7	10.9	45
46	45.3	08.0	45.2	08.8	45.1	09.0	45.0	09.6	44.8	10.3	44.6	11.1	46
47	46.3	08.2	46.1	09.0	46.1	09.2	46.0	09.8	45.8	10.6	45.6	11.4	47
48	47.3	08.3	47.1	09.2	47.1	09.4	47.0	10.0	46.8	10.8	46.6	11.6	48
49	48.3	08.5	48.1	09.3	48.1	09.6	48.9	10.2	47.7	11.0	47.5	11.9	49
50	49.2	08.7	49.1	09.5	49.0	09.8	49.9	10.4	48.7	11.2	48.5	12.1	50
Dist	Dep	Lat	Dep	Lat	Dep	Dep	Dep	Lat	Dep	Lat	Dep	Lat	Dist
	80 Deg.		79 Deg.		7 Points		78 Deg.		77 Deg.		76 Deg.		

Dist.	10 Deg.		11 Deg.		1 Point		12 Deg.		13 Deg.		14 Deg.		Dist.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	50.2	08.9	50.1	09.7	50.0	10.0	49.9	10.6	49 7	11.5	49.5	12.3	51
52	51.2	09.0	51.0	09.9	51.0	10.1	50.9	10.8	50.7	11.7	50.5	12.6	52
53	52.2	09.2	52 0	10.1	52 0	10 3	51.8	11.0	51.6	11 9	51.4	12.8	53
54	53.2	09.4	53.0	10.3	53.0	10.5	52.8	11.2	52.6	12.1	52.4	13.1	54
55	54.2	09 6	54 0	10.5	53.9	10.7	53 8	11.4	53.6	12.4	53.4	13.3	55
56	55.1	09.7	55.0	10.7	54.9	10.9	54.8	11.6	54.6	12.6	54.3	13.5	56
57	56.1	09.9	56.0	10.9	55.9	11.1	55.8	11.8	55.5	12.8	55.3	13 8	57
58	57.1	10 1	56.9	11.1	56.9	11.3	56.8	12.1	56.5	13.0	56.3	14 0	58
59	58.1	10.2	57.9	11.3	57.9	11.5	57.7	12.3	57.5	13.3	57.2	14.3	59
60	59.1	10.4	58.9	11.4	58.8	11.7	58 7	12.5	58.5	13.5	58.2	14.5	60
61	60.1	10 6	59.9	11.6	59.8	11.9	59 7	12.7	59.4	13.7	59.2	14 8	61
62	61.1	10 8	60.9	11.8	60.8	12.1	60.6	12.9	60.4	13.9	60.2	15.0	62
63	62,0	10.9	61.8	12.0	61.8	12.3	61.6	13.1	61.4	14.2	61.1	15 2	63
64	63.0	11.1	62.8	12.2	62.8	12.5	62.6	13.3	62.4	14.4	62.1	15.5	64
65	64.0	11.3	63.8	12.4	63 8	12.7	63.6	13.5	63.3	14 6	63.1	15.7	65
66	65.0	11.5	64 8	12.6	64.7	12.9	64 6	13.7	64.3	14.8	64 0	16.0	66
67	66.0	11.6	65.8	12.8	65.7	13.1	65.5	13.9	65.3	15.1	65.0	16.2	67
68	67.0	11.8	66.7	13.0	66.7	13.3	66.5	14.1	66.3	15 3	66.0	16 4	68
69	68.0	12.0	67.7	13.2	67.7	13.5	67.5	14.3	67.2	15 5	66.9	16.7	69
70	68.9	12.2	68.7	13.4	68.7	13.7	68.5	14 6	68.2	15.7	67 9	16.9	70
71	69.9	12.3	69 7	13.5	69.6	13.9	69.4	14.8	69.2	16.0	68.9	17.2	71
72	70.9	12.5	70.7	13.7	70.6	14.0	70.4	15.0	70.2	16.2	69.9	17.4	72
73	71.9	12.7	71 7	13.9	71.6	14.2	71.4	15.2	71.1	16.4	70.8	17.7	73
74	72.9	12.8	72.6	14.1	72.6	14.4	72.4	15.4	72.1	16.6	71 8	17.9	74
75	73.9	13.0	73.6	14.3	73.6	14.6	73.4	15 6	73.1	16.9	72.8	18.1	75
76	74.8	13.2	74 6	14 5	74.5	14.8	74.3	15.8	74.1	17.1	73.7	18.4	76
77	75 8	13.4	75.6	14.7	75.5	15.0	75.3	16.0	75.0	17.3	74.7	18.6	77
78	76.8	13.5	76.6	14.9	76.5	15.2	76.3	16.2	76.0	17.5	75.7	18.9	78
79	77.8	13.7	77.5	15.1	77.5	15.4	77.3	16.4	77.0	17.8	76.7	19 1	79
80	78.8	13.9	78.5	15.3	78.5	15 6	78.2	16.6	78 0	18 0	77.6	19.4	80
81	79.8	14.1	79.5	15.5	79.4	15.8	79 2	16.8	78.9	18.2	78.6	19.6	81
82	80.8	14 2	80 5	15.6	80 4	16.0	80.2	17.0	79.9	18.4	79.6	19 8	82
83	81.7	14.4	81 5	15.8	81.4	16.2	81.2	17 3	80 9	18.7	80.5	20.1	83
84	82.7	14.6	82.5	16.0	82.4	16.4	82 2	17.5	81.8	18 9	81.5	20.3	84
85	83.7	14.8	83.4	16.2	83.4	16.6	83.1	17.7	82.8	19.1	82 5	20.6	85
86	84.7	14.9	84.4	16.4	84.3	16.8	84.1	17.9	83.8	19.3	83.4	20.8	86
87	85.7	15.1	85 4	16.6	85.3	17.0	85.1	18.1	84.8	19.6	84.4	21 0	87
88	86.7	15.3	86.4	16.8	86.3	17.2	86.1	18.3	85.7	19 8	85.4	21 3	88
89	87.6	15.4	87.4	17.0	87.3	17.4	87.1	18.5	86.7	20.0	86.4	21.5	89
90	88.6	15 6	88.3	17.2	88.3	17.6	88.0	18.7	87.7	20 2	87.3	21.8	90
91	89.6	15 8	89.3	17.4	89.3	17.8	89.0	18.9	88 7	20 5	88.3	22.0	91
92	90.6	16.0	90.3	17.6	90.2	17.9	90 0	19.1	89.6	20 7	89.3	22.3	92
93	91.6	16.1	91.3	17.7	91.2	18.1	91.0	19.3	90.6	20 9	90.2	22.5	93
94	92.6	16.3	92.3	17.9	92.2	18.3	91.9	19.5	91.6	21.1	91.2	22.7	94
95	93 5	16 5	93.3	18.1	93.2	18.5	92.9	19 7	92.6	21.4	92.2	23 0	95
96	94.5	16.7	94.2	18.3	94.2	18.7	93.9	20.0	93.5	21.6	93.1	23.2	96
97	95.5	16.8	95.2	18.5	95.1	18.9	94 9	20.2	94.5	21 8	94.1	23.5	97
98	96.5	17.0	96.2	18.7	96.1	19.1	95.9	20.4	95.5	22.0	95.1	23.7	98
99	97.5	17.2	97.2	18.9	97.1	19.3	96.8	20.6	96.5	22.3	96.1	23.9	99
100	98.5	17 4	98.2	19.1	98.1	19.5	97.8	20 8	97.4	22.5	97.0	24.2	100
Dist.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist.
	80 Deg.		79 Deg.		7 Points		78 Deg.		77 Deg.		76 Deg.		

Dist.	1 ¼ Point		15 Deg.		16 Deg.		1½ Point		17 Deg.		18 Deg.		Dist.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	01.0	00.2	01.0	00.3	01.0	00.3	01.0	00.3	01.0	00.3	01.0	00.3	1
2	01.9	00.5	01.9	00.5	01.9	00.6	01.9	00.6	01.9	00.6	01.9	00.6	2
3	02.9	00.7	02.9	00.8	02.9	00.8	02.9	00.9	02.9	00.9	02.9	00.9	3
4	03.9	01.0	03.9	01.0	03.8	01.1	03.8	01.2	03.8	01.2	03.8	01.2	4
5	04.8	01.2	04.8	01.3	04.8	01.4	04.8	01.5	04.8	01.5	04.8	01.5	5
6	05.8	01.5	05.8	01.5	05.8	01.7	05.7	01.7	05.7	01.8	05.7	01.9	6
7	06.8	01.7	06.8	01.8	06.7	01.9	06.7	02.0	06.7	02.0	06.7	02.2	7
8	07.8	01.9	07.7	02.1	07.7	02.2	07.7	02.3	07.6	02.3	07.6	02.5	8
9	08.7	02.2	08.7	02.3	08.7	02.5	08.6	02.6	08.6	02.6	08.6	02.8	9
10	09.7	02.4	09.7	02.6	09.6	02.8	09.6	02.9	09.6	02.9	09.5	03.1	10
11	10.7	02.7	10.6	02.8	10.6	03.0	10.5	03.2	10.5	03.2	10.5	03.4	11
12	11.6	02.9	11.6	03.1	11.5	03.3	11.5	03.5	11.5	03.5	11.4	03.7	12
13	12.6	03.2	12.6	03.4	12.5	03.6	12.4	03.8	12.4	03.8	12.4	04.0	13
14	13.6	03.4	13.5	03.6	13.5	03.9	13.4	04.1	13.4	04.1	13.3	04.3	14
15	14.5	03.6	14.5	03.9	14.4	04.1	14.4	04.4	14.3	04.4	14.3	04.6	15
16	15.5	03.9	15.5	04.1	15.4	04.4	15.3	04.6	15.3	04.7	15.2	04.9	16
17	16.5	04.1	16.4	04.4	16.3	04.7	16.3	04.9	16.3	05.0	16.2	05.3	17
18	17.5	04.4	17.4	04.7	17.3	05.0	17.2	05.2	17.2	05.3	17.1	05.6	18
19	18.4	04.6	18.4	04.9	18.3	05.2	18.2	05.5	18.2	05.6	18.1	05.9	19
20	19.4	04.9	19.3	05.2	19.2	05.5	19.1	05.8	19.1	05.8	19.0	06.2	20
21	20.4	05.1	20.3	05.4	20.2	05.8	20.1	06.1	20.1	06.1	20.0	06.5	21
22	21.3	05.3	21.2	05.7	21.1	06.1	21.1	06.4	21.0	06.4	20.9	06.8	22
23	22.3	05.6	22.2	06.0	22.1	06.3	22.0	06.7	22.0	06.7	21.9	07.1	23
24	23.3	05.8	23.2	06.2	23.1	06.6	23.0	07.0	22.9	07.0	22.8	07.4	24
25	24.2	06.1	24.1	06.5	24.0	06.9	23.9	07.3	23.9	07.3	23.8	07.7	25
26	25.2	06.3	25.1	06.7	25.0	07.2	24.9	07.5	24.9	07.6	24.7	08.0	26
27	26.2	06.6	26.1	07.0	26.0	07.4	25.8	07.8	25.8	07.9	25.7	08.3	27
28	27.2	06.8	27.0	07.2	26.9	07.7	26.8	08.1	26.8	08.2	26.6	08.7	28
29	28.1	07.0	28.0	07.5	27.9	08.0	27.8	08.4	27.7	08.5	27.6	09.0	29
30	29.1	07.3	29.0	07.8	28.8	08.3	28.7	08.7	28.7	08.8	28.5	09.3	30
31	30.1	07.5	29.9	08.0	29.8	08.5	29.7	09.0	29.6	09.1	29.5	09.6	31
32	31.0	07.8	30.9	08.3	30.8	08.8	30.6	09.3	30.6	09.4	30.4	10.0	32
33	32.0	08.0	31.9	08.5	31.7	09.1	31.6	09.6	31.6	09.6	31.4	10.2	33
34	33.0	08.3	32.8	08.8	32.7	09.4	32.5	09.9	32.5	09.9	32.3	10.5	34
35	33.9	08.5	33.8	09.1	33.6	09.6	33.5	10.2	33.5	10.2	33.3	10.8	35
36	34.9	08.7	34.8	09.3	34.6	09.9	34.4	10.4	34.4	10.5	34.2	11.1	36
37	35.9	09.0	35.7	09.6	35.6	10.2	35.4	10.7	35.4	10.8	35.2	11.5	37
38	36.9	09.2	36.7	09.8	36.5	10.5	36.4	11.0	36.3	11.1	36.1	11.7	38
39	37.8	09.5	37.7	10.1	37.5	10.7	37.3	11.3	37.3	11.4	37.1	12.0	39
40	38.8	09.7	38.6	10.4	38.5	11.0	38.3	11.6	38.3	11.7	38.0	12.4	40
41	39.8	10.0	39.6	10.6	39.4	11.3	39.2	11.9	39.2	12.0	39.0	12.7	41
42	40.7	10.2	40.6	10.9	40.4	11.6	40.2	12.2	40.2	12.3	39.9	13.0	42
43	41.7	10.4	41.5	11.1	41.3	11.8	41.1	12.5	41.1	12.6	40.9	13.3	43
44	42.7	10.7	42.5	11.4	42.3	12.1	42.1	12.8	42.1	12.9	41.8	13.6	44
45	43.6	10.9	43.5	11.6	43.3	12.4	43.1	13.1	43.0	13.1	42.8	13.9	45
46	44.6	11.2	44.4	11.9	44.2	12.7	44.0	13.4	44.0	13.4	43.7	14.2	46
47	45.6	11.4	45.4	12.2	45.2	13.0	45.0	13.6	44.9	13.7	44.7	14.5	47
48	46.6	11.7	46.4	12.4	46.1	13.2	45.9	13.9	45.9	14.0	45.7	14.8	48
49	47.5	11.9	47.3	12.7	47.1	13.5	46.9	14.2	46.9	14.3	46.6	15.1	49
50	48.5	12.1	48.3	12.9	48.1	13.8	47.8	14.5	47.8	14.6	47.6	15.4	50
	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	
	1 Point		75 Deg.		74 Deg.		6¼ Point		73 Deg.		72 Deg.		

Dist.	1¼ Point		15 Deg.		16 Deg.		1½ Point		17 Deg.		18 Deg.		Dist.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	49,5	12,4	49,3	13,2	49,0	14,1	48,8	14,8	48.8	14.9	48.5	15.8	51
52	50,4	12,6	50,2	13,5	50,0	14,3	49,7	15,1	49,7	15.2	49 4	16.1	52
53	51,4	12,9	51,2	13,7	50,9	14,6	50,7	15,3	50.7	15.5	50.4	16.4	53
54	52,4	13,1	52,2	14,0	51,9	14,9	51,7	15,7	51.6	15.8	51.3	16.7	54
55	53,3	13,4	53,1	14,2	52,9	15,2	52,6	16,0	52.6	16.1	52.3	17.0	55
56	54,3	13,6	54,1	14,5	53,8	15,4	53,6	16,2	53,5	16.4	53.3	17.3	56
57	55,3	13,9	55,1	14,8	54,8	15,7	54,5	16,5	54.5	16.7	54.2	17.6	57
58	56,3	14,1	56,0	15,0	55,8	16,0	55,5	16,8	55.5	17.0	55.2	17.9	58
59	57,2	14,3	57,0	15,3	56,7	16,3	56,5	17,1	56.4	17.3	56.1	18.2	59
60	58,2	14,6	58,0	15,5	57,7	16,5	57,4	17,4	57.4	17.6	57.1	18.5	60
61	59,2	14,8	58,9	15,8	58,6	16,8	58,4	17,7	58.3	17.8	58.0	18 8	61
62	60,1	15,1	59,9	16,0	59,6	17,1	59,3	18,0	59,3	18.1	59.0	19.2	62
63	61,1	15,3	60,9	16,3	60,6	17,4	60,3	18,3	60.2	18.4	59.9	19.5	63
64	62,1	15,6	61,8	16,6	61,5	17,6	61,2	18,6	61,2	18.7	60.9	19.8	64
65	63,0	15,8	62,8	16,8	62,5	17,9	62,2	18,9	62,2	19.0	61.8	20.1	65
66	64,0	16,0	63,7	17,1	63,4	18,2	63,2	19,2	63,1	19.3	62.8	20.4	66
67	65,0	16,3	64,7	17,3	64,4	18,5	64,1	19,4	64.1	19.6	63.7	20.7	67
68	66,0	16,5	65,7	17,6	65,4	18,7	65,1	19,7	65.0	19.9	64.7	21.0	68
69	66,9	16,8	66,6	17,9	66,3	19,0	66,0	20,0	66,0	20.2	65.6	21.3	69
70	67,9	17,0	67,6	18,1	67,3	19,3	67,0	20,3	66,9	20.5	66.6	21.6	70
71	68,9	17,3	68,6	18,4	68,3	19,6	67,9	20,6	67,9	20.8	67.5	21.9	71
72	69,8	17,5	69,5	18,6	69,2	19,8	68,9	20,9	68,8	21.1	68.5	22.2	72
73	70,8	17,7	70,5	18,9	70,2	20,1	69,9	21,2	69,8	21.3	69.4	22.6	73
74	71,8	18,0	71,5	19,2	71,1	20,4	70,8	21,5	70,8	21.6	70 4	22.9	74
75	72,7	18,2	72,4	19,4	72,1	20,7	71,8	21,8	71.7	21.9	71.3	23.2	75
76	73,7	18,5	73,4	19,7	73,1	20,9	72,7	22,1	72.7	22.2	72.3	23.5	76
77	74,7	18,7	74,4	19,9	74,0	21,2	73,7	22,4	73.6	22.5	73.2	23.8	77
78	75,7	18,9	75,3	20,2	75,0	21,5	74,6	22,6	74.6	22.8	74.2	24.1	78
79	76,6	19,2	76,3	20,4	75,9	21,8	75,6	22,9	75.5	23.1	75.1	24.4	79
80	77,6	19,4	77,3	20,7	76,9	22,0	76,6	23,2	76,5	23.4	76.1	24.7	80
81	78,6	19,7	78,2	21,0	77,9	22,3	77,5	23,6	77,5	23.7	77.0	25.0	81
82	79,5	19,9	79,2	21,2	78,8	22,6	78,5	23,8	78,4	24.0	78.0	25.3	82
83	80,5	20,2	80,2	21,5	79,8	22,9	79,4	24,1	79.4	24 3	78.9	25.6	83
84	81,5	20,4	81,1	21,7	80,7	23,1	80,4	24,4	80,3	24 5	79.9	26.0	84
85	82,4	20,7	82,1	22,0	81,7	23,4	81,3	24,7	81,3	24.8	80.8	26.3	85
86	83,4	20,9	83,1	22,3	82,7	23,7	82,3	25,0	82,2	25.1	81.8	26.6	86
87	84,4	21,1	84,0	22,5	83,6	24,0	83,3	25,3	83.2	75.4	82.7	26.9	87
88	85,4	21,4	85,0	22,8	84,6	24,3	84,2	25,5	84,2	25.7	83.7	27.2	88
89	86,3	21,6	86,0	23,0	85,6	24,5	85,2	25,8	85.1	26.0	84.6	27 5	89
90	87,3	21,9	86,9	23,3	86,5	24,8	86,1	26,1	86,1	26.3	85.6	27.8	90
91	88,3	22,1	87,9	23,5	87,5	25,1	87,1	26,4	87.0	26.6	86.5	28.1	91
92	89,2	22,4	88,9	23,8	88,4	25,4	88,0	26,7	88,0	26.9	87.5	28.4	92
93	90.2	22,6	89,8	24,1	89,4	25,6	89,0	27,0	88.9	27.2	88.4	28.7	93
94	91,2	22,8	90,8	24,3	90,4	25,9	90,0	27,3	89 9	27.5	89.4	29.0	94
95	92,1	23,1	91,8	24,6	91,3	26,2	90,9	27,6	90.8	27.8	90.4	29.4	95
96	93,1	23,3	92,7	24,8	92,3	26,5	91,9	27,9	91,8	28.1	91.3	29.7	96
97	94,1	23,6	93,7	25,1	93,2	26,7	92,8	28,2	92.8	28.4	92.3	30 0	97
98	95,1	23,8	94,7	25,4	94,2	27,0	93,8	28,4	93.7	28.7	93.2	30.3	98
99	96,0	24,1	95,6	25,6	95,2	27,3	94,7	28,7	94.7	28.9	94.2	30.6	99
100	97,0	24,3	96,6	25,9	96,1	27,6	95,7	29,0	95,6	29.2	95.1	30.9	100
Dist.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist.
	6¼ Point		75 Deg.		74 Deg.		6½ Point		73 Deg.		72 Deg.		

Diff	19 Deg.		1¼ Point		20 Deg.		21 Deg.		22 Deg.		2 Points		Diff
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	00,9	00,3	00,9	00,3	00,9	00,3	00,9	00,4	00,9	00,4	00,9	00,4	1
2	01,9	00,7	01,9	00,7	01,9	00,7	01,9	00,7	01,9	00,7	01,8	00,8	2
3	02,8	01,0	02,8	01,0	02,8	01,0	02,8	01,1	02,8	01,1	02,8	01,1	3
4	03,8	01,3	03,8	01,3	03,8	01,4	03,7	01,4	03,7	01,5	03,7	01,5	4
5	04,7	01,6	04,7	01,7	04,7	01,7	04,7	01,8	04,6	01,9	04,6	01,9	5
6	05,7	02,0	05,6	02,0	05,6	02,1	05,6	02,1	05,6	02,2	05,5	02,3	6
7	06,6	02,3	06,6	02,4	06,6	02,4	06,5	02,5	06,5	02,6	06,5	02,7	7
8	07,6	02,6	07,5	02,7	07,5	02,7	07,5	02,9	07,4	03,0	07,4	03,1	8
9	08,5	02,9	08,5	03,0	08,5	03,1	08,4	03,2	08,3	03,4	08,3	03,4	9
10	09,5	03,3	09,4	03,4	09,4	03,4	09,3	03,6	09,3	03,7	09,2	03,8	10
11	10,4	03,6	10,4	03,7	10,3	03,8	10,3	03,9	10,2	04,1	10,2	04,2	11
12	11,3	03,9	11,3	04,0	11,3	04,1	11,2	04,3	11,1	04,5	11,1	04,6	12
13	12,3	04,2	12,2	04,4	12,2	04,4	12,2	04,7	12,1	04,9	12,0	05,0	13
14	13,2	04,6	13,2	04,7	13,2	04,8	13,1	05,0	13,0	05,2	12,9	05,4	14
15	14,2	04,9	14,1	05,1	14,1	05,1	14,0	05,4	13,9	05,6	13,9	05,7	15
16	15,1	05,2	15,1	05,4	15,0	05,5	04,9	05,7	14,8	06,0	14,8	06,1	16
17	16,1	05,5	16,0	05,7	16,0	05,8	05,9	06,1	15,8	06,4	15,7	06,5	17
18	17,0	05,9	16,9	06,1	16,9	06,2	06,8	06,4	16,7	06,7	16,6	06,9	18
19	18,0	06,2	17,9	06,4	17,9	06,5	07,7	06,8	17,6	07,1	17,6	07,3	19
20	18,9	06,5	18,8	06,7	18,8	06,8	08,7	07,2	18,5	07,5	18,5	07,7	20
21	19,9	06,8	19,8	07,1	19,7	07,2	19,6	07,5	19,5	07,9	19,4	08,0	21
22	20,8	07,2	20,7	07,4	20,7	07,5	20,5	07,9	20,4	08,2	20,3	08,4	22
23	21,7	07,5	21,7	07,7	21,6	07,9	21,5	08,2	21,3	08,6	21,2	08,8	23
24	22,7	07,8	22,6	08,1	22,6	08,2	22,4	08,6	22,3	09,0	22,2	09,2	24
25	23,6	08,1	23,5	08,4	23,5	08,5	23,3	09,0	23,2	09,4	23,1	09,6	25
26	24,6	08,5	24,5	08,8	24,4	08,9	24,3	09,3	24,1	09,7	24,0	09,9	26
27	25,5	08,8	25,4	09,1	25,4	09,2	25,2	09,7	25,0	10,1	24,9	10,2	27
28	26,5	09,1	26,4	09,4	26,3	09,6	26,1	10,0	26,0	10,5	25,9	10,7	28
29	27,4	09,4	27,3	09,8	27,3	09,9	27,1	10,4	26,9	10,9	26,8	11,1	29
30	28,4	09,8	28,2	10,1	28,2	10,3	28,0	10,8	27,8	11,2	27,7	11,5	30
31	29,3	10,1	29,2	10,4	29,1	10,6	28,9	11,1	28,7	11,6	28,6	11,9	31
32	30,3	10,4	30,1	10,8	30,1	10,9	29,9	11,5	29,7	12,0	29,6	12,3	32
33	31,2	10,7	31,1	11,1	31,0	11,3	30,8	11,8	30,6	12,4	30,5	12,6	33
34	32,1	11,1	32,0	11,5	31,9	11,6	31,7	12,2	31,5	12,7	31,4	13,0	34
35	33,1	11,4	33,0	11,8	32,9	12,0	32,7	12,5	32,5	13,1	32,3	13,4	35
36	34,0	11,7	33,9	12,1	33,8	12,3	33,6	12,9	33,4	13,5	33,3	13,8	36
37	35,0	12,0	34,8	12,5	34,8	12,7	34,5	13,3	34,3	13,9	34,2	14,2	37
38	35,9	12,4	35,8	12,8	35,7	13,0	35,5	13,6	35,2	14,2	35,1	14,5	38
39	36,9	12,7	36,7	13,1	36,6	13,3	36,4	14,0	36,2	14,6	36,0	14,9	39
40	37,8	13,0	37,7	13,5	37,6	13,7	37,3	14,3	37,1	15,0	37,0	15,3	40
41	38,8	13,3	38,6	13,8	38,5	14,0	38,3	14,7	38,0	15,4	37,9	15,7	41
42	39,7	13,7	39,5	14,1	39,5	14,4	39,2	15,1	38,9	15,7	38,8	16,1	42
43	40,7	14,0	40,5	14,5	40,4	14,7	40,1	15,4	39,9	16,1	39,7	16,5	43
44	41,6	14,3	41,4	14,8	41,3	15,0	41,1	15,8	40,8	16,5	40,7	16,8	44
45	42,5	14,7	42,4	15,2	42,3	15,4	42,0	16,1	41,7	16,9	41,6	17,2	45
46	43,5	15,0	43,3	15,5	43,2	15,7	42,9	16,5	42,7	17,2	42,5	17,6	46
47	44,4	15,3	44,2	15,8	44,2	16,1	43,9	16,8	43,6	17,6	43,4	18,0	47
48	45,4	15,6	45,2	16,2	45,1	16,4	44,8	17,2	44,5	18,0	44,3	18,4	48
49	46,3	16,0	46,1	16,5	46,0	16,8	45,7	17,6	45,4	18,4	45,3	18,8	49
50	47,3	16,3	47,1	16,8	47,0	17,1	46,7	17,9	46,4	18,7	46,2	19,1	50
Diff	Dep	Lat	Dep	Lat	Dep	Dep	Dep	Lat	Dep	Lat	Dep	Lat	Diff
	71 Deg.		6¼ Point		70 Deg.		69 Deg.		68 Deg.		6 Points		

Dist	19 Deg.		1¼ Point		20 Deg.		21 Deg.		22 Deg.		2 Points		Dist
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	48.2	16,6	48,0	17,2	47,9	17,4	47,6	18,3	47,3	19,1	47.1	19,5	51
52	49.2	16,9	49,0	17,5	48,9	17,8	48,5	18,6	48,2	19,5	48.0	19,9	52
53	50.1	17,3	49,9	17,9	49,8	18,1	49,5	19,0	49,1	19,9	49.0	20,3	53
54	51.0	17,6	50,8	18,2	50,7	18,5	50,4	19,4	50,1	20,2	49.9	20.7	54
55	52.0	17,9	51,8	18,5	51,7	18,8	51,3	19,7	51,0	20,6	50.8	21,0	55
56	52.9	18,2	52,7	18,9	52,6	19,2	52,3	20,1	51,9	21,0	51.7	21,4	56
57	53.9	18,6	53.7	19,2	53,6	19,5	53,2	20,4	52,8	21,4	52.7	21,8	57
58	54.8	18,9	54,6	19,5	54,5	19,8	54,1	20,8	53,8	21,7	53.6	22,2	58
59	55.8	19,2	55,5	19,9	55,4	20,2	55,1	21,1	54,7	22,1	54.5	22,6	59
60	56.7	19,5	56,5	20,2	56,4	20,5	56,0	21.5	55,6	22,5	55.4	23,0	60
61	57.7	19,9	57,4	20,6	57,3	20,9	56,9	21,9	56,5	22,8	56.4	23,3	61
62	58.6	20,2	58,4	20,9	58,3	21,2	57,9	22,2	57,5	23,2	57.3	23,7	62
63	59.6	20,5	59,3	21,2	59,2	21,5	58,8	22,6	58,4	23,6	58.2	24,1	63
64	60.5	20,8	60,3	21,6	60,1	21,9	59,7	22,9	59,3	24,0	59.1	24,5	64
65	61.5	21,2	61,2	21,9	61,1	22,2	60,7	23,3	60,3	24,3	60.1	24,9	65
66	62.4	21,5	62,1	22,2	62,0	22,6	61,6	23,7	61,2	24,7	61.0	25,3	66
67	63.3	21,8	63,1	22,6	63,0	22,9	62,6	24,0	62,1	25,1	61.9	25,6	67
68	64.3	22,1	64,0	22,9	63,9	23,3	63,5	24,4	63,0	25,5	62.8	26,0	68
69	65.2	22,5	64,9	23,2	64,8	23,6	64,4	24,7	64,0	25,8	63.7	26,4	69
70	66.2	22,8	65,9	23,6	65,8	23,9	65.4	25,1	64,9	26,2	64.7	26,8	70
71	67.1	23,1	66,8	23 9	66,7	24,3	66,3	25,4	65,8	26,6	65.6	27,2	71
72	68.1	23,4	67,8	24,3	67,7	24,6	67,2	25,8	66,8	27.0	66.5	27,6	72
73	69.0	23,8	68,7	24,6	68,6	25,0	68,2	26,2	67,7	27,3	67.4	27,9	73
74	70.0	24,1	69,7	24,9	69,5	25,3	69,1	26,5	68,6	27,7	68.4	28,3	74
75	70.9	24,4	70,6	25,3	70,5	25,6	70,0	26,9	69,5	28,1	69.3	28,7	75
76	71.9	24,7	71,6	25,6	71,4	26,0	71,0	27,2	70,5	28,5	70.2	29,1	76
77	72.8	25,1	72,5	25,9	72,4	26,3	71,9	27,6	71,4	28,8	71.1	29,5	77
78	73.7	25,4	73,4	26,3	73,3	26,7	72,8	28,0	72,3	29,2	72.1	29,8	78
79	74.7	25,7	74,4	26,6	74,2	27,0	73,8	28,3	73,2	29,6	73.0	30,2	79
80	75.6	26,0	75,3	27,0	75,2	27,4	74,7	28.7	74,2	30,0	73.9	30,6	80
81	76.6	26,4	76,3	27,3	76,1	27,7	75,6	29,0	75,1	30,3	74.8	31,0	81
82	77.5	26,7	77,2	27,6	77,1	28,0	76,6	29,4	76,0	30,7	75.8	31,4	82
83	78.5	27,0	78,1	28,0	78,0	28,4	77,5	29,7	77,0	31,1	76.7	31,8	83
84	79.4	27,3	79,1	28,3	78,9	28,7	78,5	30,1	77,9	31,5	77.6	32,1	84
85	80.4	27,7	80,0	28,6	79,9	29,1	79,4	30,5	78,8	31,8	78.5	32,5	85
86	81.3	28,0	81,0	29,0	80,8	29,4	80,3	30,8	79,7	32,2	79.5	32,9	86
87	82.3	28,3	81,9	29,3	81,8	29,8	81,2	31,2	80,7	32,6	80.4	33,3	87
88	83.2	28,7	82,9	29,6	82,7	30,1	82.2	31,5	81,6	33,0	81.3	33,7	88
89	84.1	29,0	83,8	30,0	83,6	30,4	83,1	31,9	82,5	33,3	82.2	34,1	89
90	85.1	29,3	84,7	30,3	84,6	30,8	84,0	32,3	83,4	33,7	83.2	34,4	90
91	86.0	29,6	85,7	30,7	85,5	31,1	85,0	32,6	84,4	34,1	84.1	34,8	91
92	87.0	30,0	86,6	31,0	86,5	31,5	85,9	33,0	85,3	34,5	85.0	35,2	92
93	87.9	30,3	87,6	31,3	87,4	31,8	86,8	33,3	86,2	34,8	85.9	35,6	93
94	88.9	30,6	88,5	31,7	88,3	32,1	87,8	33,7	87,2	35,2	86.8	36,0	94
95	89.8	30,9	89,4	32,0	89,3	32,5	88,7	34,0	88,1	35,6	87.8	36,4	95
96	90,8	31,3	90,4	32,3	90,2	32,8	89,6	34,4	89,0	36,0	88.7	36,7	96
97	91,7	31,6	91,3	32,7	91,1	33,2	90,6	34,8	89,9	36,3	89.6	37,1	97
98	92,7	31,9	92,3	33,0	92,1	33,5	91,5	35,1	90,9	36,7	90.5	37,5	98
99	93,6	32,2	93,2	33,4	93,0	33,9	92,4	35,5	91,8	37,1	91.5	37,9	99
100	94,5	32,6	94,2	33,7	94,0	34,2	93,4	35,8	92,7	37,5	92.4	38,3	100
Dist	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist
	71 Deg.		6¼ Point		70 Deg.		69 Deg.		68 Deg.		6 Points		

Diff.	23 Deg		24 Deg.		25 Deg		2¼ Point		26 Deg.		27 Deg.		Diff.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	00.9	00.4	00.9	00.4	00.9	00.4	00.9	00.4	00.9	00.4	00.9	00.5	1
2	01.8	00.8	01.8	00.8	01.8	00.8	01.8	00.9	01.8	00.9	01.8	00.9	2
3	02.8	01.2	02.7	01.2	02.7	01.3	02.7	01.3	02.7	01.3	02.7	01.4	3
4	03.7	01.6	03.6	01.6	03.6	01.7	03.6	01.7	03.6	01.8	03.6	01.8	4
5	04.6	02.0	04.6	02.0	04.5	02.1	04.5	02.1	04.5	02.2	04.5	02.3	5
6	05.5	02.3	05.5	02.4	05.4	02.5	05.4	02.6	05.4	02.6	05.3	02.7	6
7	06.4	02.7	06.4	02.8	06.3	03.0	06.3	03.0	06.3	03.1	06.2	03.2	7
8	07.4	03.1	07.3	03.3	07.2	03.4	07.2	03.4	07.2	03.5	07.1	03.6	8
9	08.4	03.5	08.2	03.7	08.2	03.8	08.1	03.8	08.1	03.9	08.0	04.1	9
10	09.2	03.9	09.1	04.1	09.1	04.2	09.0	04.3	09.0	04.4	08.9	04.5	10
11	10.1	04.3	10.0	04.5	10.0	04.6	09.9	04.7	09.9	04.8	09.8	05.0	11
12	11.0	04.7	11.0	04.9	10.9	05.1	10.8	05.1	10.8	05.3	10.7	05.4	12
13	12.0	05.1	11.9	05.3	11.8	05.5	11.8	05.6	11.7	05.7	11.6	05.9	13
14	12.9	05.5	12.8	05.7	12.7	05.9	12.7	06.0	12.6	06.1	12.5	06.4	14
15	13.8	05.9	13.7	06.1	13.6	06.3	13.6	06.4	13.5	06.6	13.4	06.8	15
16	14.7	06.2	14.6	06.5	14.5	06.8	14.5	06.8	14.4	06.9	14.3	07.3	16
17	15.6	06.6	15.5	06.9	15.4	07.2	15.4	07.3	15.3	07.5	15.1	07.7	17
18	16.6	07.0	16.4	07.3	16.3	07.6	16.3	07.7	16.2	07.9	16.0	08.2	18
19	17.5	07.4	17.4	07.7	17.2	08.0	17.2	08.1	17.1	08.3	16.9	08.6	19
20	18.4	07.8	18.3	08.1	18.1	08.5	18.1	08.6	18.0	08.8	17.8	09.1	20
21	19.3	08.2	19.2	08.5	19.0	08.9	19.0	09.0	18.9	09.2	18.7	09.5	21
22	20.3	08.6	20.1	08.9	19.9	09.3	19.9	09.4	19.8	09.6	19.6	10.0	22
23	21.2	09.0	21.0	09.4	20.8	09.7	20.8	09.8	20.7	10.1	20.5	10.4	23
24	22.1	09.4	21.9	09.8	21.8	10.1	21.7	10.3	21.6	10.5	21.4	10.9	24
25	23.0	09.8	22.8	10.2	22.7	10.6	22.6	10.7	22.5	11.0	22.3	11.3	25
26	23.9	10.2	23.8	10.6	23.6	11.0	23.5	11.1	23.4	11.4	23.2	11.8	26
27	24.9	10.5	24.7	11.0	24.5	11.4	24.4	11.5	24.3	11.8	24.1	12.3	27
28	25.8	10.9	25.6	11.4	25.4	11.8	25.3	12.0	25.2	12.3	24.9	12.7	28
29	26.7	11.3	26.5	11.8	26.3	12.3	26.2	12.4	26.1	12.7	25.8	13.2	29
30	27.6	11.7	27.4	12.2	27.2	12.7	27.1	12.8	27.0	13.2	26.7	13.6	30
31	28.5	12.1	28.3	12.6	28.1	13.1	28.0	13.3	27.9	13.6	27.6	14.1	31
32	29.5	12.5	29.2	13.0	29.0	13.5	28.9	13.7	28.8	14.0	28.5	14.5	32
33	30.4	12.9	30.1	13.4	29.9	13.9	29.8	14.1	29.7	14.5	29.4	15.0	33
34	31.3	13.3	31.1	13.8	30.8	14.4	30.7	14.5	30.6	14.9	30.3	15.4	34
35	32.2	13.7	32.0	14.2	31.7	14.8	31.6	15.0	31.5	15.3	31.2	15.9	35
36	33.1	14.1	32.9	14.6	32.6	15.2	32.5	15.4	32.4	15.8	32.1	16.3	36
37	34.1	14.5	33.8	15.0	33.5	15.6	33.4	15.8	33.3	16.2	33.0	16.8	37
38	35.0	14.8	34.7	15.5	34.4	16.1	34.4	16.2	34.2	16.7	33.9	17.3	38
39	35.9	15.2	35.6	15.9	35.3	16.5	35.3	16.7	35.1	17.1	34.7	17.7	39
40	36.8	15.6	36.5	16.3	36.3	16.9	36.2	17.1	36.0	17.5	35.6	18.2	40
41	37.7	16.0	37.5	16.7	37.2	17.3	37.1	17.5	36.8	18.0	36.5	18.6	41
42	38.7	16.4	38.4	17.1	38.1	17.7	38.0	18.0	37.7	18.4	37.4	19.1	42
43	39.6	16.8	39.3	17.5	39.0	18.2	38.9	18.4	38.6	18.9	38.3	19.5	43
44	40.5	17.2	40.2	17.9	39.9	18.6	39.8	18.8	39.5	19.3	39.2	20.0	44
45	41.4	17.6	41.1	18.3	40.8	19.0	40.7	19.2	40.4	19.7	40.1	20.4	45
46	42.3	18.0	42.0	18.7	41.7	19.4	41.6	19.7	41.3	20.2	41.0	20.9	46
47	43.3	18.4	42.9	19.1	42.6	19.9	42.5	20.1	42.2	20.6	41.9	21.3	47
48	44.2	18.8	43.8	19.5	43.5	20.3	43.4	20.5	43.1	21.0	42.8	21.8	48
49	45.1	19.2	44.8	19.9	44.4	20.7	44.3	20.9	44.0	21.5	43.7	22.2	49
50	46.0	19.5	45.7	20.3	45.3	21.1	45.2	21.4	44.9	21.9	44.6	22.7	50
Diff.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Diff.
	67 Deg		66 Deg.		65 Deg.		5¼ Point		64 Deg.		63 Deg.		

Dist	23 Deg.		24 Deg.		25 Deg.		2¼ Point		26 Deg.		27 Deg.		Dist
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	46.9	19.9	46.6	20.7	46.2	21.6	46.1	21.8	45.8	22.4	45.4	23.2	51
52	47.9	20.3	47.5	21.1	47.1	22.0	47.0	22.2	46.7	22.8	46.3	23.6	52
53	48.8	20.7	48.4	21.6	48.0	22.4	47.9	22.7	47.6	23.2	47.2	24.1	53
54	49.7	21.1	49.3	22.0	48.9	22.8	48.8	23.1	48.5	23.7	48.1	24.5	54
55	50.6	21.5	50.2	22.4	49.8	23.2	49.7	23.5	49.4	24.1	49.0	25.0	55
56	51.5	21.9	51.2	22.8	50.8	23.7	50.6	23.9	50.3	24.5	49.9	25.4	56
57	52.5	22.3	52.1	23.2	51.7	24.1	51.5	24.4	51.2	25.0	50.8	25.9	57
58	53.4	22.7	53.0	23.6	52.6	24.5	52.4	24.8	52.1	25.4	51.7	26.3	58
59	54.3	23.1	53.9	24.0	53.5	24.9	53.3	25.2	53.0	25.9	52.6	26.8	59
60	55.2	23.4	54.8	24.4	54.4	25.4	54.2	25.7	53.9	26.3	53.5	27.2	60
61	56.1	23.8	55.7	24.8	55.3	25.8	55.1	26.1	54.8	26.7	54.4	27.7	61
62	57.1	24.2	56.6	25.2	56.2	26.2	56.0	26.5	55.7	27.2	55.2	28.1	62
63	58.0	24.6	57.5	25.6	57.1	26.6	57.0	26.9	56.6	27.6	56.1	28.6	63
64	58.9	25.0	58.5	26.0	58.0	27.0	57.9	27.4	57.5	28.1	57.0	29.1	64
65	59.8	25.4	59.4	26.4	58.9	27.5	58.8	27.8	58.4	28.5	57.9	29.5	65
66	60.8	25.8	60.3	26.8	59.8	27.9	59.7	28.2	59.3	28.9	58.8	30.0	66
67	61.7	26.2	61.2	27.2	60.7	28.3	60.6	28.6	60.2	29.4	59.7	30.4	67
68	62.6	26.6	62.1	27.7	61.6	28.7	61.5	29.1	61.1	29.8	60.6	30.9	68
69	63.5	27.0	63.0	28.1	62.5	29.2	62.4	29.5	62.0	30.2	61.5	31.3	69
70	64.4	27.3	63.9	28.5	63.4	29.6	63.3	29.9	62.9	30.7	62.4	31.8	70
71	65.4	27.7	64.9	28.9	64.3	30.0	64.2	30.4	63.8	31.1	63.3	32.2	71
72	66.3	28.1	65.8	29.3	65.3	30.4	65.1	30.8	64.7	31.6	64.2	32.7	72
73	67.2	28.5	66.7	29.7	66.2	30.8	66.0	31.2	65.6	32.0	65.0	33.1	73
74	68.1	28.9	67.6	30.1	67.1	31.3	66.9	31.6	66.5	32.4	65.9	33.6	74
75	69.0	29.3	68.5	30.5	68.0	31.7	67.8	32.1	67.4	32.9	66.8	34.1	75
76	70.0	29.7	69.4	30.9	68.9	32.1	68.7	32.5	68.3	33.3	67.7	34.5	76
77	70.9	30.1	70.3	31.3	69.8	32.5	69.6	32.9	69.2	33.8	68.6	35.0	77
78	71.8	30.5	71.3	31.7	70.7	33.0	70.5	33.3	70.1	34.2	69.5	35.4	78
79	72.7	30.9	72.2	32.1	71.6	33.4	71.4	33.8	71.0	34.6	70.4	35.9	79
80	73.6	31.3	73.1	32.5	72.5	33.8	72.3	34.2	71.9	35.1	71.3	36.3	80
81	74.6	31.6	74.0	32.9	73.4	34.2	73.2	34.6	72.8	35.5	72.2	36.8	81
82	75.5	32.0	74.9	33.3	74.3	34.7	74.1	35.1	73.7	35.9	73.1	37.2	82
83	76.4	32.4	75.8	33.7	75.2	35.1	75.0	35.5	74.6	36.4	74.0	37.7	83
84	77.3	32.8	76.7	34.1	76.1	35.5	75.9	35.9	75.5	36.8	74.8	38.1	84
85	78.2	33.2	77.6	34.6	77.0	35.9	76.8	36.3	76.4	37.3	75.7	38.6	85
86	79.2	33.6	78.6	35.0	77.9	36.3	77.7	36.8	77.3	37.7	76.6	39.0	86
87	80.1	34.0	79.5	35.4	78.8	36.8	78.6	37.2	78.2	38.1	77.5	39.5	87
88	81.0	34.4	80.4	35.8	79.8	37.2	79.6	37.6	79.1	38.6	78.4	40.0	88
89	81.9	34.8	81.3	36.2	80.7	37.6	80.5	38.1	80.0	39.0	79.3	40.4	89
90	82.8	35.2	82.2	36.6	81.6	38.0	81.4	38.5	80.9	39.5	80.2	40.9	90
91	83.8	35.6	83.1	37.0	82.5	38.5	82.3	38.9	81.8	39.9	81.1	41.3	91
92	84.7	35.9	84.0	37.4	83.4	38.9	83.2	39.3	82.7	40.3	82.0	41.8	92
93	85.6	36.3	85.0	37.8	84.3	39.3	84.1	39.8	83.6	40.8	82.9	42.2	93
94	86.5	36.7	85.9	38.2	85.2	39.7	85.0	40.2	84.5	41.2	83.8	42.7	94
95	87.4	37.1	86.8	38.6	86.1	40.1	85.9	40.6	85.4	41.6	84.6	43.1	95
96	88.3	37.5	87.7	39.0	87.0	40.6	86.8	41.0	86.3	42.1	85.5	43.6	96
97	89.3	37.9	88.6	39.4	87.9	41.0	87.7	41.5	87.2	42.5	86.4	44.0	97
98	90.2	38.4	89.5	39.9	88.8	41.4	88.6	41.9	88.1	43.0	87.3	44.5	98
99	91.2	38.7	90.4	40.3	89.7	41.8	89.5	42.3	89.0	43.4	88.2	44.9	99
100	92.0	39.1	91.4	40.7	90.6	42.3	90.4	42.8	89.9	43.8	89.1	45.4	100
Dist	Dep	Lat	Dep	Lat	Dep	L at	Dep	Lat	Dep	Lat	Dep	Lat	Dist
	67 Deg.		66 Deg.		65 Deg.		3¼ Point		64 Deg.		63 Deg.		

Dist	28 Deg.		2½ Point		29 Deg.		30 Deg.		2¾ Point		31 Deg.		Dist
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	00,9	00,5	00,9	00,5	00,9	00,5	00,9	00,5	00,9	00,5	00,9	00,5	1
2	01,8	00,9	01,8	00,9	01,7	01,0	01,7	01,0	01,7	01,0	01,7	01,0	2
3	02,6	01,4	02,6	01,4	02,6	01,5	02,6	01,5	02,6	01,5	02,6	01,5	3
4	03,5	01,9	03,5	01,9	03,5	01,9	03,5	02,0	03,4	02,1	03,4	02,1	4
5	04,4	02,3	04,4	02,4	04,4	02,4	04,3	02,5	04,3	02,6	04,3	02,6	5
6	05,3	02,8	05,3	02,8	05,2	02,9	05,2	03,0	05,1	03,1	05,1	03,1	6
7	06,2	03,3	06,2	03,3	06,1	03,4	06,1	03,5	06,0	03,6	06,0	03,6	7
8	07,1	03,8	07,1	03,8	07,0	03,9	06,9	04,0	06,9	04,1	06,9	04,1	8
9	07,9	04,2	07,9	04,2	07,9	04,4	07,8	04,5	07,7	04,6	07,7	04,6	9
10	08,8	04,7	08,8	04,7	08,7	04,8	08,7	05,0	08,6	05,1	08,6	05,1	10
11	09,7	05,2	09,7	05,2	09,6	05,3	09,5	05,5	09,4	05,7	09,4	05,7	11
12	10,6	05,6	10,6	05,7	10,5	05,8	10,4	06,0	10,3	06,2	10,3	06,2	12
13	11,5	06,1	11,5	06,1	11,4	06,3	11,3	06,5	11,1	06,7	11,1	06,7	13
14	12,4	06,6	12,3	06,6	12,2	06,8	12,1	07,0	12,0	07,2	12,0	07,2	14
15	13,2	07,0	13,2	07,1	13,1	07,3	13,0	07,5	12,9	07,7	12,9	07,7	15
16	14,1	07,5	14,1	07,5	14,0	07,8	13,9	08,0	13,7	08,2	13,7	08,2	16
17	15,0	08,0	15,0	08,0	14,9	08,2	14,7	08,5	14,6	08,7	14,6	08,8	17
18	15,9	08,5	15,9	08,5	15,7	08,7	15,6	09,0	15,4	09,3	15,4	09,3	18
19	16,8	08,9	16,8	09,0	16,6	09,2	16,5	09,5	16,3	09,8	16,3	09,8	19
20	17,7	09,4	17,6	09,4	17,5	09,7	17,3	10,0	17,2	10,3	17,1	10,3	20
21	18,5	09,9	18,5	09,9	18,4	10,2	18,2	10,5	18,0	10,8	18,0	10,8	21
22	19,4	10,3	19,4	10,4	19,2	10,7	19,1	11,0	18,9	11,3	18,9	11,3	22
23	20,3	10,8	20,3	10,8	20,1	11,1	19,9	11,5	19,7	11,8	19,7	11,8	23
24	21,2	11,3	21,2	11,3	21,0	11,6	20,8	12,0	20,6	12,3	20,6	12,3	24
25	22,1	11,7	22,0	11,8	21,9	12,1	21,6	12,5	21,4	12,9	21,4	12,9	25
26	23,0	12,2	22,9	12,3	22,7	12,6	22,5	13,0	22,3	13,4	22,3	13,4	26
27	23,8	12,7	23,8	12,7	23,6	13,1	23,4	13,5	23,2	13,9	23,1	13,9	27
28	24,7	13,1	24,7	13,2	24,5	13,6	24,2	14,0	24,0	14,4	24,0	14,4	28
29	25,6	13,6	25,6	13,7	25,4	14,1	25,1	14,5	24,9	14,9	24,9	14,9	29
30	26,5	14,1	26,5	14,1	26,2	14,5	26,0	15,0	25,7	15,4	25,7	15,4	30
31	27,4	14,6	27,3	14,6	27,1	15,0	26,8	15,5	26,6	15,9	26,6	16,0	31
32	28,3	15,0	28,2	15,1	28,0	15,5	27,7	16,0	27,4	16,4	27,4	16,5	32
33	29,1	15,5	29,1	15,6	28,9	16,0	28,6	16,5	28,3	17,0	28,3	17,0	33
34	30,0	16,0	30,0	16,0	29,7	16,5	29,4	17,0	29,2	17,5	29,1	17,5	34
35	30,9	16,4	30,9	16,5	30,6	17,0	30,3	17,5	30,0	18,0	30,0	18,0	35
36	31,8	16,9	31,7	17,0	31,5	17,5	31,2	18,0	30,9	18,5	30,9	18,5	36
37	32,7	17,4	32,6	17,4	32,4	17,9	32,0	18,5	31,7	19,0	31,7	19,1	37
38	33,5	17,8	33,5	17,9	33,2	18,4	32,9	19,0	32,6	19,5	32,6	19,6	38
39	34,4	18,3	34,4	18,4	34,1	18,9	33,8	19,5	33,4	20,0	33,4	20,1	39
40	35,3	18,8	35,3	18,9	35,0	19,4	34,6	20,0	34,3	20,6	34,3	20,6	40
41	36,2	19,2	36,2	19,3	35,9	19,9	35,5	20,5	35,5	21,1	35,1	21,1	41
42	37,1	19,7	37,0	19,8	36,7	20,4	36,4	21,0	36,0	21,6	36,0	21,6	42
43	38,0	20,2	37,9	20,3	37,6	20,8	37,2	21,5	36,9	22,1	36,9	22,1	43
44	38,8	20,7	38,8	20,7	38,5	21,3	38,1	22,0	37,7	22,6	37,7	22,7	44
45	39,7	21,1	39,7	21,2	39,4	21,8	39,0	22,5	38,6	23,1	38,6	23,2	45
46	40,6	21,6	40,6	21,7	40,2	22,3	39,8	23,0	39,5	23,6	39,4	23,7	46
47	41,5	22,1	41,4	22,2	41,1	22,8	40,7	23,5	40,3	24,2	40,3	24,2	47
48	42,4	22,5	42,3	22,6	42,0	23,3	41,6	24,0	41,2	24,7	41,1	24,7	48
49	43,3	23,0	43,2	23,1	42,9	23,8	42,4	24,5	42,0	25,2	42,0	25,2	49
50	44,1	23,5	44,1	23,6	43,7	24,2	43,3	25,0	42,9	25,7	42,9	25,7	50
	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	
	62 Deg.		5½ Point		61 Deg.		60 Deg.		5½ Point		59 Deg.		

Diff.	28 Deg.		2½ Point		29 Deg.		30 Deg.		2¾ Point		31 Deg.		Diff.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	45.0	23.9	45.0	24.0	44.6	24.7	44.2	25.5	43.7	26.2	43.7	26.3	51
52	45.9	24.4	45.9	24.5	45.5	25.2	45.0	26.0	44.6	26.7	44.6	26.8	52
53	46.8	24.9	46.7	25.0	46.4	25.7	45.9	26.5	45.5	27.2	45.4	27.3	53
54	47.7	25.4	47.6	25.5	47.2	26.2	46.8	27.0	46.3	27.8	46.3	27.8	54
55	48.6	25.8	48.5	25.9	48.1	26.7	47.6	27.5	47.2	28.3	47.1	28.3	55
56	49.4	26.3	49.4	26.4	49.0	27.1	48.5	28.0	48.0	28.8	48.0	28.8	56
57	50.3	26.8	50.3	26.9	49.9	27.6	49.4	28.5	48.9	29.3	48.9	29.4	57
58	51.2	27.2	51.2	27.3	50.7	28.1	50.2	29.0	49.7	29.8	49.7	29.9	58
59	52.1	27.7	52.0	27.8	51.6	28.6	51.1	29.5	50.6	30.3	50.6	30.4	59
60	53.0	28.2	52.9	28.3	52.5	29.1	52.0	30.0	51.5	30.8	51.4	30.9	60
61	53.9	28.6	53.8	28.8	53.3	29.6	52.8	30.5	52.3	31.4	52.3	31.4	61
62	54.7	29.1	54.7	29.2	54.2	30.1	53.7	31.0	53.2	31.9	53.1	31.9	62
63	55.6	29.6	55.6	29.7	55.1	30.5	54.6	31.5	54.0	32.4	54.0	32.4	63
64	56.5	30.0	56.4	30.2	56.0	31.0	55.4	32.0	54.9	32.9	54.9	33.0	64
65	57.4	30.5	57.3	30.6	56.8	31.5	56.3	32.5	55.7	33.4	55.7	33.5	65
66	58.3	31.0	58.2	01.1	57.7	32.0	57.2	33.0	56.6	33.9	56.6	34.0	66
67	59.2	31.4	59.1	31.6	58.6	32.5	58.0	33.5	57.5	34.4	57.4	34.5	67
68	60.0	31.9	60.0	32.1	59.5	33.0	58.9	34.0	58.3	35.0	58.3	35.0	68
69	60.9	32.4	60.9	32.5	60.3	33.5	59.8	34.5	59.2	35.5	59.1	35.5	69
70	61.8	32.9	61.7	33.0	61.2	33.9	60.6	35.0	60.0	36.0	60.0	36.0	70
71	62.7	33.3	62.6	33.5	62.1	34.4	61.5	35.5	60.9	36.5	60.9	36.6	71
72	63.6	33.8	63.5	33.9	63.0	34.9	62.4	36.0	61.8	37.0	61.7	37.1	72
73	64.5	34.3	64.4	34.4	63.8	35.4	63.2	36.5	62.6	37.5	62.6	37.6	73
74	65.3	34.7	65.3	34.9	64.7	35.9	64.0	37.0	63.5	38.0	63.4	38.1	74
75	66.2	35.2	66.1	35.4	65.6	36.4	64.9	37.5	64.3	38.6	64.3	38.6	75
76	67.1	35.7	67.0	35.8	66.5	36.8	65.8	38.0	65.2	39.1	65.1	39.1	76
77	68.0	36.2	67.9	36.3	67.3	37.3	66.7	38.5	66.0	39.6	66.0	39.7	77
78	68.9	36.6	68.8	36.8	68.2	37.8	67.5	39.0	66.9	40.1	66.9	40.2	78
79	69.7	37.1	69.7	37.2	69.1	38.3	68.4	39.5	67.8	40.6	67.7	40.7	79
80	70.6	37.6	70.6	37.7	70.0	38.8	69.3	40.0	68.6	41.1	68.6	41.2	80
81	71.5	38.0	71.4	38.2	70.8	39.3	70.1	40.5	69.5	41.6	69.4	41.7	81
82	72.4	38.5	72.3	38.6	71.7	39.8	71.0	41.0	70.3	42.2	70.3	42.2	82
83	73.3	39.0	73.2	39.1	72.6	40.2	71.9	41.5	71.2	42.7	71.1	42.7	83
84	74.2	39.4	74.1	39.6	73.5	40.7	72.7	42.0	72.0	43.2	72.0	43.3	84
85	75.0	39.9	75.0	40.1	74.3	41.2	73.6	42.5	72.9	43.7	72.9	43.8	85
86	75.9	40.4	75.8	40.5	75.2	41.7	74.5	43.0	73.8	44.2	73.7	44.3	86
87	76.8	40.8	76.7	41.0	76.1	42.2	75.3	43.5	74.6	44.7	74.6	44.8	87
88	77.7	41.3	77.6	41.5	77.0	42.7	76.2	44.0	75.5	45.2	75.4	45.3	88
89	78.6	41.8	78.5	42.0	77.8	43.1	77.1	44.5	76.3	45.8	76.3	45.8	89
90	79.5	42.3	79.4	42.4	78.7	43.6	77.9	45.0	77.2	46.3	77.1	46.3	90
91	80.3	42.7	80.3	42.9	79.6	44.1	78.8	45.5	78.1	46.8	78.0	46.9	91
92	81.2	43.2	81.1	43.4	80.5	44.6	79.7	46.0	78.9	47.3	78.9	47.4	92
93	82.1	43.7	82.0	43.8	81.3	45.1	80.5	46.5	79.8	47.8	79.7	47.9	93
94	83.0	44.1	82.9	44.3	82.2	45.6	81.4	47.0	80.6	48.3	80.6	48.4	94
95	83.9	44.6	83.8	44.8	83.1	46.1	82.3	47.5	81.5	48.8	81.4	48.9	95
96	84.8	45.1	84.7	45.2	84.0	46.5	83.1	48.0	82.3	49.3	82.3	49.4	96
97	85.6	45.5	85.5	45.7	84.8	47.0	84.0	48.5	83.2	49.9	83.1	50.0	97
98	86.5	46.0	86.4	46.2	85.7	47.5	84.9	49.0	84.1	50.4	84.0	50.5	98
99	87.4	46.5	87⅓	46.7	86.6	48.0	85.7	49.5	84.9	50.9	84.9	51.0	99
100	88.3	46.9	88.2	47.1	87.5	48.5	86.6	50.0	85.8	51.4	85.7	51.5	100
Diff.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Diff.
	62 Deg.		5½ Point		61 Deg.		60 Deg.		5¼ Point		59 Deg.		

Diff.	32 Deg.		33 Deg		3 Points		34 Deg.		35 Deg.		36 Deg.		Diff.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	00.8	00.5	00.8	00.5	00.8	00.6	00.8	00.6	00.8	00.6	00.8	00.6	1
2	01.7	01.1	01.7	01.1	01.7	01.1	01 6	01.1	01.6	01.1	01.6	01.2	2
3	02.5	01.6	02.5	01.6	02.5	01.7	02.5	01.7	02.5	01.7	02.4	01.8	3
4	03.4	02.1	03.4	02.2	03.3	02.2	03.3	02.2	03.3	02.3	03.2	02.4	4
5	04 2	02.6	04.2	02.7	04.2	02.8	04.1	02.8	04.1	02.9	04.0	02.9	5
6	05.1	03.2	05.0	03.3	05 0	03.3	05.0	03.3	04.9	03.4	04.9	03.5	6
7	05.9	03.7	05.9	03.8	05.8	03.9	05 8	03.9	05.7	04 0	05.7	04.1	7
8	06,8	04.2	06.7	04.4	06.6	04 4	06.6	04.5	06.6	04.6	06.5	04.7	8
9	07.6	04.8	07.5	04.9	07.5	05.0	07.5	05.0	07.4	05.2	07.3	05.3	9
10	08.5	05.3	08.4	05.4	08.3	05.6	08.3	05.6	08.2	05.7	08.1	05 9	10
11	09.3	05.8	09.2	06.0	09.1	06.1	09.1	06.2	09 0	06.3	08.9	06.5	11
12	10.2	06.4	10.1	06.5	10.0	06.7	09.9	06.7	09.8	06.9	09.7	07.0	12
13	11.0	06.9	10.9	07.1	10.8	07.2	10.8	07.3	10.6	07.5	10.5	07.6	13
14	11.9	07.4	11.7	07.6	11.6	07.8	11.6	07.8	11.5	08.0	11.3	08.2	14
15	12.7	07.9	12.6	08.2	12.5	08.3	12.4	08.3	12.3	08.6	12.1	08.8	15
16	13.6	08.5	13.4	08.7	13.3	08.9	13.3	08.9	13.1	09.2	12.9	09.4	16
17	14.4	09.0	14.3	09.3	14.1	09.4	14.1	09.5	13.9	09.8	13.8	10.0	17
18	15.3	09.5	15.1	09.8	15 0	10.0	14.9	10.1	14.7	10.3	14.6	10.6	18
19	16.1	10.1	15.9	10.3	15.8	10.6	15.8	10.6	15.6	10 9	15.4	11.2	19
20	17.0	10.6	16 8	10.9	16.6	11.1	16.6	11.2	16.4	11.5	16.2	11.8	20
21	17.8	11.1	17.6	11.4	17.5	11.7	17.4	11.7	17.2	12.0	17.0	12.3	21
22	18.7	11.7	18.5	12.0	18.3	12.2	18.2	12.3	18.0	12.6	17.8	12.9	22
23	19.5	12.2	19.3	12.5	19.1	12.8	19.1	12.9	18.8	13.2	18.6	13.5	23
24	20.4	12.7	20.1	13.1	20.0	13.3	19.9	13.4	19.7	13.8	19.4	14.1	24
25	21.2	13.2	21.0	13.6	20.8	13 9	20.7	14.0	20.5	14.3	20.2	14.7	25
26	22.0	13.8	21.8	14.2	21.6	14.4	21.6	14.5	21.3	14.9	21.0	15.3	26
27	22.9	14.3	22.6	14 7	22.4	15.0	22.4	15.1	22,1	15.5	21.8	15.9	27
28	23.7	14.8	23.5	15.2	23 3	15.6	23.2	15,7	22.9	16.1	22.7	16.5	28
29	24.6	15.4	24.3	15.8	24.1	16.1	24.0	16.2	23.8	16.6	23.5	17.0	29
30	25.4	15.9	25.2	16.3	24.9	16.7	24 9	16.8	24.6	17.2	24.3	17.6	30
31	26.3	16.4	26.0	16.9	25 8	17 2	25.7	17.3	25.4	17.8	25.1	18.2	31
32	27.1	17.0	26 8	17.4	26.6	17.8	26.5	17 9	26.2	18.4	25.9	18.8	32
33	28.0	17.5	27.7	18.0	27.4	18.3	27.4	18 5	27.0	18.9	26.7	19.4	33
34	28.8	18.0	28.5	18.5	28 3	18.9	28.2	19.0	27.9	19.5	27.5	20 0	34
35	29.7	18.5	29.4	19.1	29.1	19.4	29 0	19.6	28.7	20.1	28.3	20.6	35
36	30.5	19.1	30.2	19.6	29.9	20.0	29.8	20.1	29.5	20.6	29.1	21.2	36
37	31.4	19.6	31.0	20.1	30.8	20 6	30.7	20.7	30.3	21.2	29.9	21.7	37
38	32.2	20.1	31.9	20.7	31.6	21.1	31.5	21.2	31.1	21.8	30.7	22.3	38
39	33.1	20.7	32.7	21.2	32 4	21.7	32.3	21.8	32.0	22.4	31.6	22.9	39
40	33.9	21.2	33.6	21.8	33.3	22,2	33.2	22.4	32.8	22.9	32.4	23.5	40
41	34.8	21.7	34.4	22.3	34.1	22.8	34 0	22 9	33.6	23.5	33.2	24.1	41
42	35 6	22.3	35 2	22.9	34.9	23.3	34.8	23.5	34.4	24.1	34 0	24.7	42
43	36.5	22.8	36.1	23.4	35.8	23 9	35.6	24.0	35.2	24.7	34.8	25.3	43
44	37.3	23.3	36.9	24.0	36.6	24.4	36.5	24 6	36.0	25.2	35.6	25.9	44
45	38.2	23.8	37.7	24.5	37.4	25.0	37.3	25.2	36.9	25.8	36.4	26.5	45
46	39.0	24.4	38.6	25.1	38,2	25.6	38.1	25.7	37.7	26.4	37.2	27.0	46
47	39.9	24.9	39.4	25.6	39.1	26 1	39.0	26 3	38 5	27.0	38.0	27.6	47
48	40 7	25.4	40.3	26.1	39.9	26.7	39.8	26.8	39.3	27.5	38.8	28 2	48
49	41.6	26.0	41.1	26.7	40.7	27.2	40.6	27.4	40.1	28.1	39.6	28.8	49
50	42.4	26 5	41.9	27.2	41.6	27.8	41.4	28.0	41.0	28.7	40.4	29.4	50
Diff.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Diff.
	58 Deg.		57 Deg.		5 Points		56 Deg.		55 Deg.		54 Deg.		

Diff.	32 Deg.		33 Deg.		3 Points		34 Deg.		35 Deg.		36 Deg.		Diff.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	43,2	27,0	42,8	27,8	42,4	28,3	42,3	28,5	41,8	29.3	41.3	30.0	51
52	44,1	27,6	43,6	28,3	43,2	28,9	43,1	29,1	42,6	29.8	42.1	30.6	52
53	44,9	28,1	44,5	28,9	44,1	29,4	43,9	29,6	43.4	30.4	42.9	31.2	53
54	45,8	28,6	45,3	29,4	44,9	30,0	44,8	30,2	44,2	31.0	43.7	31.7	54
55	46,6	29,1	46,1	30,0	45,7	30,6	45,6	30,8	45.1	31.5	44.5	32.3	55
56	47,5	29,7	47,0	30,5	46,6	31,1	46,4	31,3	45.9	32.1	45 3	32 9	56
57	48,3	30,2	47,8	31,0	47,4	31,7	47,3	31,9	46,7	32.7	46.1	33.5	57
58	49,2	30,7	48,6	31,6	48,2	32,2	48,1	32,4	47.5	33.3	46.9	34.1	58
59	50,0	31,3	49.5	32,1	49,1	32,8	48,9	33,0	48,3	33.8	47.7	34.7	59
60	50,9	31,8	50,3	32,7	49,9	33,3	49,7	33,6	49,2	34.4	48.5	35.3	60
61	51,7	32,3	51,2	33,2	50,7	33,9	50,6	34,1	50.0	35.0	49 3	35.9	61
62	52,6	32,8	52,0	33,8	51,6	34,4	51,4	34,7	50.8	35.6	50.2	36.4	62
63	53,4	33,4	52,8	34,3	52,4	35,0	52,2	35,2	5 .6	36.1	51.0	37.0	63
64	54,3	33,9	53,7	34,9	53,2	35,6	53,1	35,8	52.4	36.7	51.8	37.6	64
65	55,1	34,4	54,5	35,4	54,0	36,1	53,9	36,3	53,2	37.3	52 6	38.2	65
66	56,0	35,0	55,4	35,9	54,9	36,7	54,7	36,9	54,1	37 9	53.4	38.8	66
67	56,8	35,5	56,2	36,5	55,7	37,2	55,5	37,5	54,9	38.4	54.2	39 4	67
68	57.7	36,0	57,0	37,0	56,5	37,8	56,4	38,0	55.7	39.0	55.0	40.0	68
69	58,5	36,6	57,9	37,6	57,4	38,3	57,2	38,6	56 5	39.6	55.8	40.6	69
70	59,4	37,1	58,7	38,1	58,2	38,9	58,0	39,1	57.3	40.2	56.6	41.1	70
71	60,2	37,6	59,5	38,7	59,0	39,4	58,9	39,7	58.2	40.7	57.4	41.7	71
72	61,1	38,2	60,4	39,2	59,9	40,0	59,7	40,3	59,0	41.3	58.2	42.3	72
73	61,9	38,7	61,2	39,8	60,7	40,6	60,5	40,8	59.8	41.9	59.1	42.9	73
74	62,8	39,2	62,1	40,3	61,5	41,1	61,3	41,4	60.6	42.4	59 9	43.5	74
75	63,6	39,7	62,9	40,8	62,4	41,7	62,2	41,9	61,4	43.0	60.7	44.1	75
76	64,4	40,3	63,7	41,4	63.2	42,2	63,0	42,5	62,3	43.6	61.5	44.7	76
77	65,3	40,8	64,6	41,9	64,0	42,8	63,8	43,1	63,1	44.2	62.3	45.3	77
78	66,1	41,3	65,4	42,5	64,9	43,3	64,7	43,6	63.9	44.7	63.1	45.8	78
79	67,0	41,9	66,3	43,0	65,7	43,9	65,5	44,2	64.7	45.3	63,9	46.4	79
80	67,8	42,4	67,1	43,6	66,5	44,4	66,3	44,7	65.5	45.9	64.7	47.0	80
81	68,7	42,9	67,9	44,1	67,4	45,0	67,1	45,3	66,4	46.5	65 5	47.6	81
82	69,5	43,4	68,8	44,7	68,2	45,6	68,0	45,9	67,2	47.0	66.3	48.2	82
83	70,4	44,0	69,6	45,2	69,0	46,1	68,8	46,4	68,0	47.6	67.1	48 8	83
84	71,2	44,5	70,5	45,7	69,8	46,7	69,6	47,0	68.8	48.2	68.0	49.4	84
85	72,1	45,0	71,3	46,3	70,7	47,2	70,5	47,5	69,6	48.8	68.8	50.0	85
86	72,9	45,6	72,1	46,8	71,5	47,8	71,3	48,1	70,5	49.3	69.6	50.5	86
87	73,8	46,1	73,0	47,4	72,3	48,3	72,1	48,6	71.3	49.9	70 4	51.1	87
88	74,6	46,6	73,8	47,9	73,2	48,9	73,0	49,2	72.1	50.5	71.2	51.7	88
89	75,5	47,2	74,6	48,5	74,0	49,4	73,8	49,8	72.9	51.0	72.0	52.3	89
90	76,3	47,7	75,5	49,0	74,8	50,0	74,6	50,3	73.7	51.6	72.8	52.9	90
91	77,2	48,2	76,3	49,6	75,7	50,6	75,4	50,9	74.5	52.2	73.6	53.5	91
92	78,0	48,7	77,2	50,1	76,5	51,1	76,3	51,4	75.4	52.8	74.4	54.1	92
93	78,9	49,3	78,0	50,6	77,3	51,7	77,1	52,0	76,2	53.3	75.2	54.7	93
94	79,7	49,8	78,8	51,2	78,2	52,2	77,9	52,6	77,0	53.9	76.0	55 3	94
95	80,6	50,3	79,7	51,7	79,0	52,8	78,8	53,1	77.8	54.5	76.9	55.8	95
96	81,4	50,9	80,5	52,3	79,8	53,3	79,6	53,7	78,6	55.1	77.7	56.4	96
97	82,3	51,4	81,4	52,8	80,7	53,9	80,4	54,2	79.5	55.6	78.5	57.0	97
98	83,1	51,9	82,2	53,4	81,5	54,4	81,2	54,8	80,3	56.2	79.3	57.6	98
99	84,0	52,5	83,0	53,9	82,3	55,0	82,1	55,4	81,1	56.8	80.1	58.2	99
100	84,8	53,0	83,9	54,5	83,1	55,6	82,9	55,9	81,9	57 4	80.9	58.8	100
Diff.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Diff.
	58 Deg.		57 Deg.		5 Points		56 Deg.		55 Deg.		54 Deg.		

Diff.	3¼ Point		37 Deg.		38 Deg.		39 Deg.		3¼ Point		40 Deg.		Diff.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	00.8	00.6	00.8	00.6	00.8	00.6	00.8	00.6	00.8	00.6	00.8	00.6	1
2	01.6	01.2	01.6	01.2	01.6	01.2	01.6	01.3	01.5	01.3	01.5	01.3	2
3	02.4	01.8	02.4	01.8	02.4	01.8	02.3	01.9	02.3	01.9	02.3	01.9	3
4	03.2	02.4	03.2	02.4	03.2	02.5	03.1	02.5	03.1	02.5	03 1	02.6	4
5	04 0	03.0	04.0	03.0	03.9	03.1	03.9	03.1	03.9	03.2	03.8	03 2	5
6	04.8	03.6	04.8	03.6	04.7	03.7	04.7	03.8	04.6	03,8	04.6	03 9	6
7	05.6	04.2	05 6	04.2	05.5	04.3	05 4	04.4	05 4	04.4	05.4	04 5	7
8	06.4	04 8	06.4	04.8	06.3	04 9	06,2	05 0	06.2	05.1	06.1	05.1	8
9	07.2	05 4	07.2	05 4	07.1	05 5	07.0	05.7	07.0	05.7	06 9	05 8	9
10	08 0	06.0	08 0	06.0	07 9	06 2	07 8	06.3	07.7	06.3	07.7	06 4	10
11	08 8	06 6	08 8	06.6	08.7	06 8	08.5	06.9	08.5	07.0	08.4	07.1	11
12	09.6	07.1	09 6	07.2	09 5	07.4	09.3	07.6	09.3	07.6	09.2	07.7	12
13	10.4	07.7	10.4	07.8	10.2	08.0	10.1	08.2	10 0	08.2	10.0	08.4	13
14	11.2	08 3	11.2	08.4	11.0	08.6	10 9	08.8	10.8	08.9	10.7	09.0	14
15	12 0	03.9	12.0	09.0	11 8	09 2	11.7	09.4	11.6	09.5	11.5	09.6	15
16	12.9	09.5	12.8	09.6	12.6	09.9	12 4	10.1	12.4	10 1	12.3	10.3	16
17	13.7	10.1	13.6	10.2	13.4	10.5	13.2	10.7	13.1	10.8	13.0	10.9	17
18	14 5	10.7	14 4	10.8	14 2	11.1	14 0	11.3	13.9	11.4	13.8	11.6	18
19	15.3	11.3	15.2	11.4	15.0	11.7	14 8	12.0	14.7	12.1	14.6	12.2	19
20	16.1	11.9	16.0	12 0	15.8	12.3	15 5	12.6	15 5	12.7	15.3	12 9	20
21	16.9	12.5	16.8	12.6	16.5	12.9	16 3	13.2	16 2	13.3	16.1	13.5	21
22	17.7	13.1	17.6	13.2	17.3	13.5	17.1	13.8	17.0	14.0	16.9	14.1	22
23	18.5	13.7	18 4	13.8	18.1	14 2	17 9	14 5	17.8	14.6	17.6	14.8	23
24	19.3	14.3	19.2	14.4	18.9	14.8	18.6	15.1	18.6	15.2	18 4	15.4	24
25	20.1	14.9	20 0	15.0	19.7	15.4	19.4	15.7	19.3	15.9	19.1	16.1	25
26	20 9	15.5	20.8	15 6	20.5	16.0	20 2	16 4	20 1	16.5	19.9	16.7	26
27	21.7	16.1	21.6	16.2	21.3	16.6	21.0	17.0	20 9	17.1	20.7	17.4	27
28	22.5	16 7	22.4	16.8	22.1	17.2	21.8	17.6	21.6	17.8	21 4	18.0	28
29	23.3	17.3	23 2	17.5	22 9	17.9	22.5	18.2	22 4	18.4	22.2	18.6	29
30	24.1	17.9	24.0	18 1	23.6	18.5	23.3	18 9	23 2	19.0	23.0	19.3	30
31	24.9	18.5	24 8	18.7	24.4	19.1	24 1	19.5	24.0	19.7	23.7	19.9	31
32	25.7	19.1	25 6	19 3	25.2	19.7	24.9	20.1	24 7	20.3	24.5	20.6	32
33	26.5	19.7	26.4	19 9	26.0	20 3	25 6	20.8	25.5	20.9	25.3	21.2	33
34	27.3	20 3	27.2	20.5	26 8	20.9	26.4	21.4	26.3	21.6	26.0	21.9	34
35	28.1	20 8	28 0	21.1	27.6	21.5	27.2	22.0	27.1	22.2	26.8	22.5	35
36	28.9	21 4	28.7	21.7	28.4	22 2	28 0	22 7	27.8	22.8	27.6	23.1	36
37	29.7	22.0	29.5	22.3	29.2	22.8	28.8	23.3	28 6	23 5	28.3	23.8	37
38	30.5	22.6	30.3	22 9	29.9	23 4	29 5	23.9	29 4	24.1	29.1	24.4	38
39	31.3	23.2	31.1	23.5	30.7	24 0	30.3	24.5	30.1	24.7	29.9	25 1	39
40	32.1	23.8	31.9	24 1	31.5	24.6	31.1	25 2	30.9	25 4	30.6	25.7	40
41	32.9	24 4	32.7	24.7	32 3	25.2	31 9	25.8	31.7	26.0	31.4	26 4	41
42	33.7	25 0	33.5	25.3	33.1	25.9	32 6	26.4	32 5	26 6	32.2	27.0	42
43	34.5	25.6	34.3	25 9	33 9	26.5	33.4	27.1	33.2	27 3	32.9	29.6	43
44	35.3	26 2	35.1	26 5	34.7	27.1	34 2	27.7	34.0	27.9	33.7	28.3	44
45	36.1	26.8	35 9	27.1	35 5	27.7	35 0	28.3	34 8	28.5	34.5	28.9	45
46	36.9	27.4	36.7	27.7	36.2	28 3	35 7	28.9	35.6	29 2	35.2	29 6	46
47	37.7	28.0	37.5	28.3	37.0	28 9	36.5	29.6	36.3	29.8	36.0	30.2	47
48	38 6	28.6	38.3	28.9	37.8	29 6	37.3	30.2	37.1	30.5	36.8	30.9	48
49	39.4	29.2	39.1	29.5	38.6	30.2	38.1	30.8	37.9	31.1	37.5	31.5	49
50	40.2	29.8	39.9	30.1	39.4	30.8	38 9	31.5	38.6	31.7	38.3	32.1	50
Diff.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Diff.
	4¼ Point		53 Deg.		52 Deg.		51 Deg.		4¼ Point		50 Deg.		

Dist.	3¼ Point		37 Deg.		38 Deg.		39 Deg.		3½ Point		40 Deg.		Dist.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	41.0	30.4	40.7	30.7	40.2	31.4	39.6	32.1	39.4	32.4	39.1	32.8	51
52	41.8	31.0	41.5	31.3	41 0	32.0	40.4	32 7	40.2	33.0	39.8	33.4	52
53	42.6	31.6	42.3	31.9	41.8	32.6	41.2	33.4	41.0	33.6	40.6	34.1	53
54	43.4	32.2	43.1	32.5	42.6	33.2	42.0	34.0	41.7	34.3	41.4	34.7	54
55	44.2	32.8	43.9	33.1	43.3	33.9	42.7	34.6	42.5	34.9	42.1	35.4	55
56	45.0	33.4	44.7	33.7	44.1	34.5	43.5	35.2	43.3	35.5	42.9	36.0	56
57	45.8	34.0	45.5	34.3	44.9	35.1	44.3	35.9	44.1	36.2	43.7	36.6	57
58	46.6	34.5	46 3	34.9	45 7	35.7	45.1	36.5	44.8	36.8	44.4	37.3	58
59	47.4	35.1	47.1	35.5	46 5	36.3	45.8	37.1	45.6	37.4	45.2	37.9	59
60	48.2	35.7	47.9	36.1	47.3	36.9	46.6	37.8	46.4	38.1	46.0	38.6	60
61	49.0	36.3	48.7	36 7	48.1	37.6	47.4	38.4	47.2	38 7	46.7	39.2	61
62	49.8	36.9	49.5	37.3	48.9	38.2	48.2	39.0	47.9	39.3	47.5	39.9	62
63	50.6	37.5	50.3	37.9	49.6	38.8	49.0	39 6	48.7	40.0	48.3	40.5	63
64	51.4	38.1	51.1	38.5	50 4	39.4	49.7	40 3	49.5	40.6	49.0	41.1	64
65	52.2	38.7	51.9	39.1	51.2	40.0	50.5	40.9	50.2	41.2	49.8	41.8	65
66	53.0	39.3	52.7	39.7	52.0	40.6	51.3	41.5	51.0	41.9	50.6	42.4	66
67	53.8	39.9	53 5	40.3	52.8	41.3	52.1	42.2	51.8	42.5	51.3	43.1	67
68	54.6	40.5	54.3	40 9	53.6	41.9	52.8	42.8	52.6	43.1	52.1	43.7	68
69	55.4	41.1	55.1	41.5	54.4	42.5	53.6	43.4	53.3	43.8	52.9	44.4	69
70	56 2	41.7	55 9	42.1	55.2	43.1	54.4	44.1	54.1	44.4	53.6	45.0	70
71	57 0	42.3	56.7	42.7	55.9	43.7	55.2	44 7	54.9	45.0	54.4	45.6	71
72	57.8	42 9	57.5	43.3	56.7	44.3	56 0	45.3	55.7	45 7	55.2	46.3	72
73	58.6	43.5	58.3	43.9	57.5	44.9	56.7	46.9	56.4	46.3	55.9	46.9	73
74	59.4	44.1	59.1	44.5	58.3	45.6	57.5	46.6	57.2	46.9	56.7	47.6	74
75	60.2	44.7	59 9	45.1	59.1	46.2	58.3	47.2	58.0	47.6	57.5	48.2	75
76	61.0	45.3	60 7	45.7	59.9	46.8	59 1	47.8	58.7	48.2	58.2	48.9	76
77	61.8	45.9	61.5	46.3	60.7	47.4	59.8	48.5	59.5	48.8	59.0	49.5	77
78	62.6	46.5	62.3	46.9	61.5	48.0	60.6	49.1	60.3	49.5	59.7	50.1	78
79	63.5	47.1	63.1	47.5	62.3	48.6	61.4	49.7	61.1	50.1	60.5	50.8	79
80	64.3	47.7	63 9	48.1	63 0	49.3	62.2	50.3	61.8	50.8	61.3	51.4	80
81	65.1	48.3	64 7	48.7	63.8	49.9	62 9	51.0	62.6	51.4	62.0	52.1	81
82	65.9	48.8	65.5	49.3	64 6	50.5	63.7	51.6	63.4	52 0	62.8	52.7	82
83	66.7	49.4	66.3	49 9	65.4	51.1	64.5	52.2	64 2	52.7	63.6	53.4	83
84	67.5	50.0	67.1	50.6	66.2	51.7	65.3	52.9	64.9	53 3	64.3	54.0	84
85	68.3	50.6	67 9	51.2	67 0	52.3	66 1	53.5	65.7	53 9	65.1	54.6	85
86	69.1	51.2	68.7	51.8	67.8	52.9	66.8	54.1	66.5	54.6	65.9	55.3	86
87	69.9	51.8	69.5	52.4	68.6	53.6	67.6	54.7	67.3	55.2	66 6	55 9	87
88	70.7	52.4	70.3	53.0	69.3	54.2	68.4	55.4	68.0	55 8	67.4	56.6	88
89	71.5	53.0	71.1	53 6	70.1	54.8	69.2	56.0	68 8	56.5	68.2	57.2	89
90	72.3	53.6	71.9	54.2	70.9	55.4	69.9	56.6	69 6	57.1	68.9	57.9	90
91	73.1	54 2	72.7	54.8	71.7	56 0	70.7	57.3	70.3	57.7	69.7	58.3	91
92	73.9	54 8	73.5	55.4	72 5	56.6	71.5	57.9	71.1	58.4	70.5	59.1	92
93	74.7	55.4	74 3	56 0	73.3	57.3	72.3	58.5	71.9	59.0	71.2	59.8	93
94	75.5	56.0	75 1	56 6	74.1	57.9	73 0	59.2	72.7	59.6	72.0	60.4	94
95	76.3	56.6	75 9	57.2	74.9	58.5	73.8	59 8	73.4	60.3	72.8	61.1	95
96	77.1	57.2	76.7	57.8	75.6	59.1	74.6	60.4	74.2	60.9	73.5	61.7	96
97	77.9	57.8	77.5	58.4	76.4	59.7	75 4	61 0	75.0	61.5	74.3	62.4	97
98	78.7	58.4	78.3	59.0	77.2	60.3	76 2	61.7	75.8	62.2	75.1	63.0	98
99	79.5	59.0	79.1	59.6	78.0	61.0	76.9	62.3	76.5	62.8	75.8	63 6	99
100	80.3	59.6	79 9	60.2	78 8	61.6	77.7	62.9	77.3	63.4	76.6	64.3	100
Dist.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist.
	4¼ Point		53 Deg.		52 Deg.		51 Deg.		4½ Point		50 Deg.		

Dist.	41 Deg.		42 Deg.		3/4 Point		43 Deg.		44 Deg.		1/4 Points		Dist.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
1	00.8	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	00.7	1
2	01.5	01.3	01.5	01.3	01.5	01.3	01.5	01.4	01.4	01.4	01.4	01.4	2
3	02.3	02.0	02.2	02.0	02.2	02.0	02.2	02.0	02.2	02.1	02.1	02.1	3
4	03.0	02.6	03.0	02.7	03.0	02.7	03.0	02.7	02.9	02.8	02.8	02.8	4
5	03.8	03.3	03.7	03.3	03.7	03.4	03.7	03.4	03.6	03.5	03.5	03.5	5
6	04.5	03.9	04.5	04.0	04.4	04.0	04.4	04.1	04.3	04.2	04.2	04.2	6
7	05.3	04.6	05.2	04.7	05.2	04.7	05.1	04.8	05.0	04.9	04.9	04.9	7
8	06.0	05.2	05.9	05.4	05.9	05.4	05.9	05.5	05.8	05.6	05.7	05.7	8
9	06.8	05.9	06.7	06.0	06.7	06.0	06.6	06.1	06.5	06.3	06.4	06.4	9
10	07.5	06.6	07.4	06.7	07.4	06.7	07.3	06.8	07.2	06.9	07.1	07.1	10
11	08.3	07.2	08.2	07.4	08.2	07.4	08.0	07.5	07.9	07.6	07.8	07.8	11
12	09.1	07.9	08.9	08.0	08.9	08.1	08.8	08.2	08.6	08.3	08.5	08.5	12
13	09.8	08.5	09.7	08.7	09.6	08.7	09.5	08.9	09.3	09.0	09.2	09.2	13
14	10.6	09.2	10.4	09.4	10.4	09.4	10.2	09.5	10.1	09.7	09.9	09.9	14
15	11.3	09.8	11.1	10.0	11.1	10.1	11.0	10.2	10.8	10.4	10.6	10.6	15
16	12.1	10.5	11.9	10.7	11.9	10.7	11.7	10.9	11.5	11.1	11.3	11.3	16
17	12.8	11.2	12.6	11.4	12.6	11.4	12.4	11.6	12.2	11.8	12.0	12.0	17
18	13.6	11.8	13.4	12.0	13.3	12.1	13.2	12.3	12.9	12.5	12.7	12.7	18
19	14.3	12.5	14.1	12.7	14.1	12.8	13.9	13.0	13.7	13.2	13.4	13.4	19
20	15.1	13.1	14.9	13.4	14.8	13.4	14.6	13.6	14.4	13.9	14.1	14.1	20
21	15.8	13.8	15.6	14.0	15.6	14.1	15.4	14.3	15.1	14.6	14.8	14.8	21
22	16.6	14.4	16.3	14.7	16.3	14.8	16.1	15.0	15.8	15.3	15.6	15.6	22
23	17.4	15.1	17.1	15.4	17.0	15.4	16.8	15.7	16.5	16.0	16.3	16.3	23
24	18.1	15.7	17.8	16.1	17.8	16.1	17.6	16.4	17.3	16.7	17.0	17.0	24
25	18.9	16.4	18.6	16.7	18.5	16.8	18.3	17.1	18.0	17.4	17.7	17.7	25
26	19.6	17.1	19.3	17.4	19.3	17.5	19.0	17.7	18.7	18.1	18.4	18.4	26
27	20.4	17.7	20.1	18.1	20.0	18.1	19.7	18.4	19.4	18.8	19.1	19.1	27
28	21.1	18.4	20.8	18.7	20.7	18.8	20.5	19.1	20.1	19.5	19.8	19.8	28
29	21.9	19.0	21.5	19.4	21.5	19.5	21.2	19.8	20.9	20.1	20.5	20.5	29
30	22.6	19.7	22.3	20.1	22.2	20.1	21.9	20.5	21.6	20.8	21.2	21.2	30
31	23.4	20.3	23.0	20.7	23.0	20.8	22.7	21.1	22.3	21.5	21.9	21.9	31
32	24.1	21.0	23.8	21.4	23.7	21.5	23.4	21.8	23.0	22.2	22.6	22.6	32
33	24.9	21.7	24.5	22.1	24.5	22.2	24.1	22.5	23.7	22.9	23.3	23.3	33
34	25.7	22.3	25.3	22.7	25.2	22.8	24.9	23.2	24.5	23.6	24.0	24.0	34
35	26.4	23.0	26.0	23.4	25.9	23.5	25.6	23.9	25.2	24.3	24.7	24.7	35
36	27.2	23.6	26.8	24.1	26.7	24.2	26.3	24.6	25.9	25.0	25.5	25.5	36
37	27.9	24.3	27.5	24.8	27.4	24.8	27.0	25.2	26.6	25.7	26.2	26.2	37
38	28.7	24.9	28.2	25.4	28.2	25.5	27.8	25.9	27.3	26.4	26.9	26.9	38
39	29.4	25.6	29.0	26.1	28.9	26.2	28.5	26.6	28.1	27.1	27.6	27.6	39
40	30.2	26.2	29.7	26.8	29.6	26.9	29.3	27.3	28.8	27.8	28.3	28.3	40
41	30.9	26.9	30.5	27.4	30.4	27.5	30.0	28.0	29.5	28.5	29.0	29.0	41
42	31.7	27.6	31.2	28.1	31.1	28.2	30.7	28.6	30.2	29.2	29.7	29.7	42
43	32.5	28.2	32.0	28.8	31.8	28.9	31.4	29.3	30.9	29.9	30.4	30.4	43
44	33.2	28.9	32.7	29.4	32.6	29.5	32.2	30.0	31.6	30.6	31.1	31.1	44
45	34.0	29.5	33.4	30.1	33.3	30.2	32.9	30.7	32.4	31.3	31.8	31.8	45
46	34.7	30.2	34.2	30.8	34.1	30.9	33.6	31.4	33.1	32.0	32.5	32.5	46
47	35.5	30.8	34.9	31.4	34.8	31.6	34.4	32.1	33.8	32.6	33.2	33.2	47
48	36.2	31.5	35.7	32.1	35.6	32.2	35.1	32.7	34.5	33.3	33.9	33.9	48
49	37.0	32.1	36.4	32.8	36.3	32.9	35.8	33.4	35.2	34.0	34.6	34.6	49
50	37.7	32.8	37.2	33.5	37.0	33.6	36.6	34.1	36.0	34.9	35.4	35.4	50
Dist.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist.
	49 Deg.		48 Deg.		4 1/4 Point		47 Deg.		46 Deg.		4 Points		

Dist.	41 Deg.		42 Deg.		3¾ Point		43 Deg.		44 Deg.		4 Points		Dist.
	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	
51	38.5	33.5	37.9	34.1	37.8	34.3	37.3	34.8	36.7	33.4	36.1	36.1	51
52	39.2	34.1	38 6	34.8	38.5	34.9	38.0	35.5	37.4	36.1	36.8	36.8	52
53	40.0	34.8	39.4	35.5	39.3	35.6	38.8	36.1	38.1	36.8	37.5	37.5	53
54	40.8	35.4	40.1	36.1	40.0	36.3	39 5	36.8	38.8	37.5	38.2	38.2	54
55	41.5	36.1	40.9	36.8	40.8	36.9	40.2	37.5	39.6	38.2	36.9	36.9	55
56	42.3	36.7	41.6	37.5	41.5	37.6	41.0	38.2	40.3	38.9	39.6	39.6	56
57	43.0	37.4	42.4	38.1	42.2	38.3	41.7	38.9	41.0	39.6	40.3	40.3	57
58	43.8	38.1	43.1	38.8	43.0	39.0	42.4	39.6	41.7	40.3	41.0	41.0	58
59	44.5	38.7	43.8	39.5	43.7	39.6	43.2	40.2	42.4	41.0	41.7	41.7	59
60	45.3	39.4	44.6	40.1	44.5	40.3	43.9	40 9	43.2	41.7	42.4	42.4	60
61	46.0	40.0	45.3	40.8	45.2	41.0	44.6	41.6	43.9	42.4	43.1	43.1	61
62	46.8	40.7	46.1	41.5	45 9	41.6	45.3	42.3	44.6	43.1	43.8	43.8	62
63	47.5	41.3	46.8	42.2	46.7	42.3	46.1	43.0	45.3	43.8	44.5	44.5	63
64	48.3	42.0	47.6	42.8	47.4	43.0	46.8	43.6	46.0	44.5	45.3	45.3	64
65	49.1	42.6	48.3	43.5	48.2	43.7	47.5	44.3	46.8	45.2	46.0	46.0	65
66	49 8	43.3	49.0	44.2	48.9	44.3	48.3	45.0	47.5	45.8	46.7	46.7	66
67	50.6	44.0	49.8	44.8	49.6	45.0	49.0	45.7	48.2	46.5	47.4	47.4	67
68	51.3	44 6	50.5	45.5	50.4	45.7	49.7	46.4	48.9	47.2	48.1	48.1	68
69	52.1	45.3	51.3	46.2	51.1	46.3	50.5	47.1	49.6	47.9	48.8	48.8	69
70	52.8	45.9	52.0	46.8	51.9	47.0	51.2	47.7	50.4	48.6	49.5	49.5	70
71	53.6	46.6	52.8	47.5	52.6	47.7	51.9	48.4	51.1	49.3	50.2	50.2	71
72	54.3	47.2	53.5	48.2	53.4	48.4	52.7	49.1	51.8	50.0	50.9	50.9	72
73	55.1	47.9	54.2	48.8	54.1	49 0	53 4	49.8	52.5	50.7	51.6	51.6	73
74	55.8	48.6	55.0	49.5	54.8	49.7	54.1	50.5	53.2	51.4	52.3	52.3	74
75	56.6	49.2	55.7	50.2	55.6	50.4	54.9	51.1	53.9	52.1	53.0	53.0	75
76	57.4	49.9	56.5	50.9	56.3	51.0	55.6	51.8	54.7	52.8	53 7	53.7	76
77	58.1	50.5	57.2	51.5	57.1	51.7	56.3	52.5	55.4	53.5	54.4	54.4	77
78	58.9	51.2	58.0	52 2	57.8	52.4	57.0	53.2	56.1	54.2	55.2	55.2	78
79	59.6	51.8	58.7	52.9	58.5	53.1	57.8	53.9	56.8	54.9	55.9	55.9	79
80	60.4	52.5	59.4	53.5	59.3	53.7	58.5	54.6	57.5	55.6	56.6	56.6	80
81	61.1	53.1	60.2	54.2	60.0	54.4	59.2	55.2	58.3	56.3	57.3	57.3	81
82	61.9	53.8	60.9	54.9	60.8	55.1	60.0	55.9	59.0	57.0	58.0	58.0	82
83	62.6	54.5	61.7	55.5	61.5	55.7	60.7	56.6	59.7	57.7	58.7	58.7	83
84	63.4	55.1	62.4	56.2	62.2	56.4	61.4	57.3	60.4	58.4	59.4	59.4	84
85	64.1	55.8	63.2	56.9	63 0	57.1	62.2	58.0	61.1	59.0	60.1	60.1	85
86	64.9	56 4	63.9	57.5	63.7	57.8	62.9	58.7	61.9	59.7	60.8	60.8	86
87	65.7	57.1	64.6	58.2	64.5	58.4	63.6	59.3	62.6	60.4	61.5	61.5	87
88	66.4	57.7	65.4	58.9	65.2	59.1	64.4	60.0	63.3	61.1	62.2	62.2	88
89	67.2	58.4	66.1	59.6	65.9	59.8	65.1	60.7	64.0	61.8	62.9	62.9	89
90	67.9	59.0	66.9	60.2	66.7	60.4	65.8	61.4	64.7	62.5	63.6	63.6	90
91	68.7	59.7	67.6	60.9	67.4	61.1	66.6	62.1	65.5	63.2	64.3	64.3	91
92	69.4	60.4	68.4	61 6	68.2	61.8	67.3	62.7	66.2	63.9	65.1	65.1	92
93	70.2	61.0	69.1	62.2	68.9	62.5	68.0	63.4	66.9	64.6	65.8	65.8	93
94	70.9	61.7	69.9	62.9	69.7	63.1	68.8	64.1	67.6	65.3	66.5	66.5	94
95	71.7	62.3	70.6	63.6	70.4	63.8	69.5	64.8	68.3	66.0	67.2	67.2	95
96	72.5	63.0	71.3	64.2	71.1	64.5	70.2	65.5	69.1	66.7	67.9	67.9	96
97	73.2	63.6	72.1	64.9	71.9	65.1	70.9	66.2	69.8	67.4	68.6	68.6	97
98	74.0	64.3	72.8	65.6	72.6	65.8	71.7	66.8	70.5	68.1	69.3	69.3	98
99	74.7	65.0	73.6	66.2	73.4	66.5	72.4	67.5	71.2	68.8	70.0	70.0	99
100	75.5	65.6	74.3	66.9	74.1	67.2	73.1	68.2	71.9	69.5	70.7	70.7	100
Dist.	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dep	Lat	Dist.
	49 Deg.		48 Deg.		4¼ Point		47 Deg.		46 Deg.		4 Points		

A

TABLE

OF

Meridional Parts,

TO EVERY

DEGREE and MINUTE

OF THE

MERIDIAN,

For performing the several Cases in

NAVIGATION,

According to

MERCATOR,

OF

Mr. *WRIGHT*'s Projection.

M	0 d	1 d	2 d	3 d	4 d	5 d	6 d	7 d	8 d	9 d	10 d	M
0	0	60	120	180	240	300	361	421	481	542	603	0
1	1	61	121	181	241	301	362	422	482	543	604	1
2	2	62	122	182	242	302	363	423	483	544	605	2
3	3	63	123	183	243	303	364	424	484	545	606	3
4	4	64	124	184	244	304	365	425	485	546	607	4
5	5	65	125	185	245	305	366	426	487	547	608	5
6	6	66	126	186	246	306	367	427	488	548	609	6
7	7	67	127	187	247	307	368	428	489	549	610	7
8	8	68	128	188	248	308	369	429	490	550	611	8
9	9	69	129	189	249	309	370	430	491	551	612	9
10	10	70	130	190	250	310	371	431	492	552	613	10
11	11	71	131	191	251	311	372	432	493	553	614	11
12	12	72	132	192	252	312	373	433	494	554	615	12
13	13	73	133	193	253	313	374	434	495	555	616	13
14	14	74	134	194	254	314	375	435	496	556	617	14
15	15	75	135	195	255	5	376	436	497	557	618	15
16	16	76	136	196	256	6	377	437	498	558	619	16
17	17	77	137	197	257	7	378	438	499	559	620	17
18	18	78	138	198	258	318	379	439	500	560	621	18
19	19	79	139	199	259	319	380	440	501	561	622	19
20	20	80	140	200	260	320	381	441	502	562	623	20
21	21	81	141	201	261	21	382	442	503	563	624	21
22	22	82	142	202	262	322	383	443	504	564	625	22
23	23	83	143	203	263	3	384	444	505	565	626	23
24	24	84	144	204	264	24	385	445	506	566	627	24
25	25	85	145	205	265	325	386	446	507	567	628	25
26	26	86	146	206	266	26	387	447	508	568	629	26
27	27	87	147	207	267	27	388	448	509	569	630	27
28	28	88	148	208	268	328	389	449	510	570	631	28
29	29	89	149	209	269	329	390	450	511	571	632	29
30	30	90	150	210	270	30	391	451	512	573	633	30
31	31	91	151	211	271	1	392	452	513	574	634	31
32	32	92	152	212	272	2	393	453	514	575	635	32
33	33	93	153	213	273	333	394	454	515	576	636	33
34	34	94	154	214	274	334	395	455	516	577	638	34
35	35	95	155	215	275	335	396	456	517	578	639	35
36	36	96	156	216	276	336	397	457	518	579	640	36
37	37	97	157	217	277	337	398	458	519	580	641	37
38	38	98	158	218	278	338	399	459	520	581	642	38
39	39	99	159	219	279	339	400	460	521	582	643	39
40	40	100	160	220	280	340	401	461	522	583	644	40
41	41	101	161	221	281	341	402	462	523	584	645	41
42	42	102	162	222	282	342	403	463	524	585	646	42
43	43	103	163	223	283	343	404	464	525	586	647	43
44	44	104	164	224	284	344	405	465	526	587	648	44
45	45	105	165	225	285	345	406	466	527	588	649	45
46	46	106	166	226	286	346	407	467	528	589	650	46
47	47	107	167	227	287	347	408	468	529	590	651	47
48	48	108	168	228	288	348	409	469	530	591	652	48
49	49	109	169	229	289	349	410	470	531	592	653	49
50	50	110	170	230	290	350	411	471	532	593	654	50
51	51	111	171	231	291	351	412	472	533	594	655	51
52	52	112	172	232	292	352	413	473	534	595	656	52
53	53	113	173	233	293	353	414	474	535	596	657	53
54	54	114	174	234	294	354	415	475	536	597	658	54
55	55	115	175	235	295	355	416	476	537	598	659	55
56	56	116	176	236	296	356	417	477	538	599	660	56
57	57	117	177	237	297	357	418	478	539	600	661	57

M	11 d	12 d	13 d	14 d	15 d	16 d	17 d	18 d	19 d	20 d	21 d	M
0	664	725	787	848	910	973	1035	1098	1161	1225	1289	0
1	665	726	788	849	911	974	36	99	62	26	90	1
2	666	727	789	850	912	975	37	1100	63	27	91	2
3	667	728	790	851	913	976	38	01	65	28	92	3
4	668	729	791	852	914	977	39	02	66	29	93	4
5	669	730	792	854	916	978	40	03	67	30	94	5
6	670	731	793	855	917	979	41	04	68	31	96	6
7	671	732	794	856	918	980	42	05	69	32	97	7
8	672	733	795	857	919	981	43	07	70	34	98	8
9	673	734	796	858	920	982	44	08	71	35	99	9
10	674	735	797	859	921	983	1045	1109	1172	1236	1300	10
11	675	736	798	860	922	984	47	10	73	37	01	11
12	676	737	799	861	923	985	48	11	74	38	02	12
13	677	738	800	862	924	986	49	12	75	39	03	13
14	678	740	801	863	925	987	50	13	76	40	04	14
15	679	741	802	864	926	988	51	14	77	41	05	15
16	680	742	803	865	927	989	52	15	78	42	06	16
17	681	743	804	866	928	990	53	16	79	43	07	17
18	682	744	805	867	929	991	54	17	80	44	08	18
19	683	745	806	868	930	992	55	18	81	45	09	19
20	684	746	807	869	931	993	1056	1119	1183	1246	1311	20
21	685	747	808	870	932	994	57	20	84	47	12	21
22	686	748	809	871	933	996	58	21	85	48	13	22
23	687	749	810	872	934	997	59	22	86	50	14	23
24	688	750	811	873	935	998	60	23	87	51	15	24
25	689	751	812	874	936	999	61	24	88	52	16	25
26	690	752	813	875	937	1000	62	25	89	53	17	26
27	691	753	814	876	938	1001	63	27	90	54	18	27
28	692	754	815	877	939	1002	64	28	91	55	19	28
29	694	755	816	878	940	1003	66	29	92	56	20	29
30	695	756	817	879	941	1004	1067	1130	1193	1257	1321	30
31	696	757	819	880	942	05	68	31	94	58	22	31
32	697	758	820	881	944	06	69	32	95	59	23	32
33	698	759	821	882	945	07	70	33	96	60	25	33
34	699	760	822	883	946	08	71	34	97	61	26	34
35	700	761	823	884	947	09	72	35	98	62	27	35
36	701	762	824	886	948	10	73	36	1200	63	28	36
37	702	763	825	887	949	11	74	37	01	64	29	37
38	703	764	826	888	950	12	75	38	02	66	30	38
39	704	765	827	889	951	13	76	39	03	67	31	39
40	705	766	828	890	952	1014	1077	1140	1204	1268	1332	40
41	706	767	839	891	953	15	78	41	05	69	33	41
42	707	768	830	892	954	16	79	42	06	70	34	42
43	708	769	831	893	955	17	80	43	07	71	35	43
44	709	770	832	894	956	18	81	44	08	72	36	44
45	710	771	833	895	957	19	82	46	09	73	37	45
46	711	772	834	896	958	20	83	47	10	74	38	46
47	712	773	835	897	959	21	84	48	11	75	40	47
48	723	774	836	898	960	23	85	49	12	76	41	48
49	714	775	837	899	961	24	87	50	13	77	42	49
50	715	776	838	900	962	1025	1088	1151	1214	1278	1343	50
51	716	777	839	901	963	26	89	52	15	79	44	51
52	717	778	840	902	964	27	90	53	16	81	45	52
53	718	779	841	903	965	28	91	54	18	82	46	53
54	719	780	842	904	966	29	92	55	19	83	47	54
55	720	782	843	905	967	30	93	56	20	84	48	55
56	721	783	844	906	968	31	94	57	21	85	49	56
57	722	784	845	907	969	32	95	58	22	86	50	57
58	723	785	846	908	971	33	96	59	23	87	51	58

M	22 d	23 d	24 d	25 d	26 d	27 d	28 d	29 d	30 d	31 d	32 d	M
0	1354	1419	1484	1550	1616	1683	1751	1819	1888	1958	2028	0
1	55	20	85	51	17	85	52	20	89	59	29	1
2	56	21	86	52	19	86	53	22	91	60	31	2
3	57	22	87	53	20	87	54	23	92	61	32	3
4	58	23	88	54	21	88	56	24	93	63	33	4
5	59	24	89	55	22	89	57	25	94	64	34	5
6	60	25	91	57	23	90	58	27	95	65	35	6
7	61	26	92	58	24	91	59	28	97	66	37	7
8	62	27	93	59	25	92	60	29	98	67	38	8
9	63	28	94	60	26	94	61	30	99	68	39	9
10	1364	1429	1495	1561	1628	1695	1762	1831	1900	1970	2040	10
11	65	30	96	62	29	96	64	32	01	71	41	11
12	67	31	97	63	30	97	65	33	02	72	42	12
13	68	33	98	64	31	98	66	34	03	73	44	13
14	69	34	99	65	32	99	67	35	04	74	45	14
15	70	35	1500	66	33	1700	68	37	06	75	46	15
16	71	36	01	68	34	01	69	38	07	77	47	16
17	72	37	03	69	35	03	70	39	08	78	48	17
18	73	38	04	70	36	04	71	40	09	79	50	18
19	74	39	05	71	38	05	73	41	10	80	51	19
20	1375	1440	1506	1572	1639	1706	1774	1842	1911	1981	2052	20
21	76	41	07	73	40	07	75	43	13	82	53	21
22	77	42	08	74	41	08	76	45	14	84	54	22
23	78	44	09	75	42	09	77	46	15	85	55	23
24	79	45	10	76	43	10	78	47	16	86	57	24
25	81	46	11	78	44	12	79	48	17	87	58	25
26	82	47	12	79	45	13	81	49	18	88	59	26
27	83	48	14	80	46	14	82	50	20	89	60	27
28	84	49	15	81	47	15	83	51	21	91	61	28
29	85	50	16	82	49	16	84	53	22	92	63	29
30	1386	1451	1517	1583	1650	1717	1785	1854	1923	1993	2064	30
31	87	52	18	84	51	18	86	55	24	94	65	31
32	88	53	19	85	52	19	87	56	25	95	66	32
33	89	54	20	86	53	21	89	57	26	97	67	33
34	90	56	21	87	54	22	90	58	28	98	69	34
35	91	57	22	89	55	23	91	59	29	99	70	35
36	92	58	23	90	57	24	92	61	30	2000	71	36
37	94	59	25	91	58	25	93	62	31	01	72	37
38	95	60	26	92	59	26	94	63	32	02	73	38
39	96	61	27	93	60	27	95	64	33	04	74	39
40	1397	1462	1528	1594	1661	1728	1797	1865	1935	2005	2076	40
41	98	63	29	95	62	30	98	66	36	06	77	41
42	99	64	30	96	63	31	99	68	37	07	78	42
43	1400	65	31	97	64	32	1800	69	38	08	79	43
44	01	66	32	99	65	33	01	70	39	09	80	44
45	02	68	33	1600	67	34	02	71	40	11	82	45
46	03	69	34	01	68	35	03	72	42	12	83	46
47	04	70	36	02	69	36	04	73	43	13	84	47
48	05	71	37	03	70	37	06	74	44	14	85	48
49	07	72	38	04	71	39	07	76	45	15	86	49
50	1408	1473	1539	1605	1672	1740	1808	1877	1946	2017	2088	50
51	09	74	40	06	73	41	09	78	47	18	89	51
52	10	75	41	07	74	42	10	79	49	19	90	52
53	11	76	42	09	76	43	11	80	50	20	91	53
54	12	77	43	10	77	44	12	81	51	21	92	54
55	13	78	44	11	78	45	14	83	52	22	93	55
56	14	80	45	12	79	47	15	84	53	24	95	56
57	15	81	47	13	80	48	16	85	54	25	96	57
58	16	82	48	14	81	49	17	86	56	26	97	58
59	17	83	49	15	82	50	18	87	57	27	98	59

M	33 d	34 d	35 d	36 d	37 d	38 d	39 d	40 d	41 d	42 d	43 d	M
0	2099	2171	2244	2318	2393	2468	2545	2623	2702	2782	2863	0
1	2101	73	45	19	94	69	45	24	03	83	64	1
2	02	74	47	20	95	71	47	25	04	84	66	2
3	03	75	48	22	96	72	49	27	06	86	67	3
4	04	76	49	23	98	73	50	28	07	87	69	4
5	05	77	50	24	99	75	51	29	08	88	70	5
6	07	79	52	25	2400	76	53	30	10	90	71	6
7	08	80	53	27	01	77	54	32	11	91	73	7
8	09	81	54	28	03	78	55	33	12	92	74	8
9	10	82	55	29	04	80	56	34	14	94	75	9
10	2111	2183	2256	2330	2405	2481	2558	2636	2715	2795	2877	10
11	13	85	58	32	06	82	59	37	16	97	78	11
12	14	86	59	33	08	83	60	38	17	98	80	12
13	15	87	60	34	09	85	62	40	19	99	81	13
14	16	88	61	35	10	86	63	41	20	2801	82	14
15	17	90	63	36	11	87	64	42	21	02	84	15
16	19	91	64	38	13	89	66	44	23	03	85	16
17	20	92	65	39	14	90	67	45	24	05	86	17
18	21	93	66	40	15	91	68	46	25	06	88	18
19	22	94	67	41	16	92	69	48	27	07	89	19
20	2123	2196	2269	2343	2418	2494	2571	2649	2728	2809	2890	20
21	25	97	70	44	19	95	72	50	29	10	92	21
22	26	98	71	45	20	96	73	51	31	11	93	22
23	27	99	72	46	21	97	75	53	32	13	95	23
24	28	2200	74	48	23	99	76	54	33	14	96	24
25	29	02	75	49	24	2500	77	55	35	15	97	25
26	31	03	76	50	25	01	78	57	36	17	99	26
27	32	04	77	51	26	03	80	58	37	18	2900	27
28	33	05	78	53	28	04	81	59	39	20	02	28
29	34	06	80	54	29	05	82	61	40	21	03	29
30	2135	2208	2281	2355	2430	2506	2584	2662	2741	2822	2904	30
31	37	09	82	56	32	08	85	63	43	24	06	31
32	38	10	83	58	33	09	86	65	44	25	07	32
33	39	11	85	59	34	10	88	66	45	26	08	33
34	40	13	86	60	35	12	89	67	47	28	10	34
35	41	14	87	61	37	13	90	69	48	29	11	35
36	43	15	88	63	38	14	91	70	49	30	13	36
37	44	16	90	64	39	15	93	71	51	32	14	37
38	45	17	91	65	40	17	94	73	52	33	15	38
39	46	19	92	66	42	18	95	74	54	34	17	39
40	2147	2220	2293	2368	2443	2519	2597	2675	2755	2836	2918	40
41	49	21	94	69	44	20	98	76	56	37	19	41
42	50	22	96	70	45	22	99	78	58	39	21	42
43	51	23	97	71	47	23	2601	79	59	40	22	43
44	52	25	98	73	48	24	02	80	60	41	24	44
45	53	26	99	74	49	26	03	82	61	43	25	45
46	55	27	2301	75	50	27	04	83	63	44	26	46
47	56	28	02	76	52	28	06	84	64	45	28	47
48	57	30	03	78	53	29	07	86	66	47	29	48
49	58	31	04	79	54	31	08	87	67	48	31	49
50	2159	2232	2306	2380	2456	2532	2610	2688	2768	2849	2932	50
51	61	33	07	81	57	33	11	90	70	51	33	51
52	62	34	08	83	58	35	12	91	71	52	35	52
53	63	36	09	84	59	36	14	92	72	54	36	53
54	64	37	11	85	61	37	15	94	74	55	37	54
55	65	38	12	86	62	38	16	95	75	56	39	55
56	67	39	13	87	63	40	17	96	76	58	40	56
57	68	41	14	88	64	41	19	98	78	59	42	57
58	69	42	15	90	66	42	20	99	79	60	43	58
59	70	43	17	91	67	44	21	2700	80	62	44	59

M	44 d	45 d	46 d	47 d	48 d	49 d	50 d	51 d	52 d	53 d	54 d	M
0	2946	3030	3116	3203	3292	3382	3474	3569	3665	3765	3865	0
1	47	31	17	04	93	84	76	70	67	67	67	1
2	49	33	18	06	95	85	78	73	69	69	69	2
3	50	34	20	07	96	87	79	74	70	70	70	3
4	51	36	21	09	98	88	81	75	72	72	72	4
5	53	37	23	10	99	90	82	77	73	73	73	5
6	54	38	24	12	3301	91	84	78	75	74	75	6
7	56	40	26	13	02	93	85	80	77	75	77	7
8	57	41	27	14	04	94	87	81	78	77	78	8
9	58	42	29	16	05	96	89	83	80	78	80	9
10	2900	3044	3130	3217	3307	3397	3490	3585	3682	3780	3882	10
11	61	45	31	19	08	99	92	86	83	82	83	11
12	63	47	33	20	10	3400	93	88	85	84	85	12
13	64	48	34	22	12	02	95	90	87	85	87	13
14	65	50	36	23	13	03	96	91	88	87	89	14
15	67	51	37	25	14	05	98	93	90	89	90	15
16	68	53	39	26	16	07	99	94	91	91	92	16
17	69	54	40	28	17	08	3501	96	93	92	94	17
18	71	55	42	29	19	10	03	98	95	94	95	18
19	72	57	43	31	20	11	04	99	96	96	97	19
20	2974	3058	3144	3232	3322	3413	3505	3600	3698	3797	3899	20
21	75	60	46	33	23	14	07	02	3700	99	3901	21
22	76	61	47	34	25	16	09	04	01	3801	02	22
23	78	63	49	35	26	17	10	05	03	02	04	23
24	79	64	50	38	28	19	12	07	05	04	06	24
25	81	65	52	40	29	20	14	09	06	06	07	25
26	82	67	53	41	31	22	15	10	08	07	09	26
27	83	68	55	42	32	23	17	12	09	09	11	27
28	85	70	56	44	34	25	18	14	11	11	13	28
29	86	71	57	45	35	27	20	15	13	12	14	29
30	2988	3073	3159	3247	3337	3428	3521	3617	3714	3814	3916	30
31	89	74	60	48	38	30	23	18	16	16	18	31
32	90	75	62	50	40	31	25	20	18	17	20	32
33	92	77	63	51	41	33	26	22	19	19	21	33
34	93	78	65	53	43	34	28	23	21	21	23	34
35	95	80	66	54	44	36	29	25	23	22	25	35
36	96	81	68	56	46	37	31	26	24	24	26	36
37	98	83	69	57	47	39	32	28	26	26	28	37
38	99	84	71	59	49	40	34	30	28	27	30	38
39	3000	85	72	60	50	42	36	31	29	29	32	39
40	3002	3087	3173	3262	3352	3443	3537	3633	3731	3831	3933	40
41	03	88	75	63	53	45	39	35	32	33	35	41
42	05	90	76	65	55	47	40	36	34	34	37	42
43	06	91	78	66	56	48	42	38	36	36	39	43
44	07	93	79	68	58	49	43	39	38	38	40	44
45	09	94	81	69	59	51	45	41	39	39	42	45
46	10	95	82	71	61	53	47	43	41	41	44	46
47	12	97	84	72	62	54	48	44	43	43	45	47
48	13	98	85	74	64	56	50	46	44	44	47	48
49	14	3100	87	75	65	57	51	48	46	46	49	49
50	3016	3101	3188	3277	3367	3459	3553	3649	3747	3848	3951	50
51	17	03	90	78	68	61	55	51	49	49	52	51
52	19	04	91	80	70	62	56	52	50	51	54	52
53	20	05	92	81	71	64	58	54	51	53	56	53
54	22	07	94	83	73	65	59	56	54	55	58	54
55	23	08	95	84	74	67	61	57	56	56	59	55
56	24	10	97	86	76	68	62	59	57	58	61	56
57	26	11	98	87	78	70	64	60	59	60	63	57
58	27	13	3200	89	79	71	66	62	60	61	65	58
59	29	14	01	90	81	73	67	64	62	63	66	59

M.	55 d	56 d	57 d	58 d	59 d	60 d	61 d	62 d	63 d	64 d	65 d	M.
0	3968	4074	4183	4294	4409	4528	4649	4775	4905	5040	5179	0
1	70	76	85	96	11	30	52	77	07	42	82	1
2	72	77	86	98	13	32	54	80	10	44	84	2
3	73	79	88	4300	15	34	56	82	12	47	86	3
4	75	81	90	02	17	36	58	84	14	49	89	4
5	77	83	92	04	19	38	60	86	16	51	91	5
6	78	85	94	06	21	40	62	88	19	53	93	6
7	80	87	96	08	23	42	64	90	21	56	96	7
8	82	88	97	10	25	44	66	92	23	58	98	8
9	83	90	99	12	27	46	68	95	26	60	5201	9
10	3986	4092	4201	4313	4429	4548	4670	4797	4927	5063	5203	10
11	87	94	03	15	31	50	72	99	30	65	05	11
12	89	95	05	17	33	52	74	4801	32	67	08	12
13	91	97	07	19	35	54	76	03	34	70	10	13
14	92	99	09	21	37	56	78	05	36	72	12	14
15	94	4100	10	23	39	58	81	07	38	74	15	15
16	96	01	12	25	41	60	83	10	41	76	17	16
17	98	03	14	27	43	62	85	12	43	79	20	17
18	4000	06	16	29	44	64	87	14	45	81	22	18
19	01	08	18	31	46	66	89	16	47	83	24	19
20	4003	4110	4220	4332	4448	4568	4691	4818	4950	5086	5227	20
21	05	12	22	34	50	70	92	20	52	88	29	21
22	06	14	23	36	52	72	95	22	54	90	31	22
23	08	15	25	38	54	74	97	25	56	93	34	23
24	10	17	27	40	56	76	99	27	59	95	36	24
25	12	19	29	42	58	78	4701	29	61	97	39	25
26	14	21	32	44	60	80	04	31	63	5100	41	26
27	15	23	33	46	62	82	06	33	65	02	44	27
28	17	24	35	48	64	84	08	35	67	04	46	28
29	19	26	36	50	66	86	10	38	70	07	48	29
30	4021	4128	4238	4352	4468	4588	4712	4840	4972	5109	5251	30
31	22	30	40	53	70	90	14	42	74	11	53	31
32	24	32	44	55	72	92	16	44	76	14	56	32
33	26	33	45	57	74	94	18	46	79	16	58	33
34	28	35	46	59	76	96	20	48	81	18	61	34
35	30	37	48	61	78	98	22	50	83	20	63	35
36	31	39	49	63	80	4600	24	53	85	23	65	36
37	33	41	51	65	82	03	27	55	88	25	68	37
38	35	43	53	67	84	04	29	57	90	27	70	38
39	37	44	55	69	86	06	31	59	92	30	73	39
40	4038	4146	4257	4371	4488	4608	4733	4861	4994	5132	5275	40
41	40	48	59	73	90	10	35	64	97	34	78	41
42	42	50	61	75	92	13	37	66	99	37	80	42
43	44	52	63	77	94	15	39	68	5001	39	83	43
44	46	54	64	78	96	17	41	70	03	42	85	44
45	47	55	66	80	98	19	43	72	06	44	87	45
46	49	57	68	82	4500	21	46	75	08	46	90	46
47	51	59	70	84	02	23	48	77	10	49	92	47
48	52	61	72	86	04	25	50	80	12	51	95	48
49	54	63	74	88	06	27	52	81	13	53	97	49
50	4056	4164	4276	4390	4508	4629	4754	4883	5017	5156	5299	50
51	58	66	78	92	10	31	56	85	20	58	5302	51
52	60	68	79	94	12	33	58	88	22	60	04	52
53	62	70	81	96	14	35	60	90	24	63	07	53
54	63	72	83	98	16	37	63	92	26	65	09	54
55	65	74	85	4400	18	39	65	94	28	67	12	55
56	67	75	87	02	20	41	67	97	31	70	14	56
57	69	77	89	04	22	43	69	99	33	72	17	57
58	70	79	91	05	24	45	71	4901	35	74	19	58

M	44 d	45 d	46 d	47 d	48 d	49 d	50 d	51 d	52 d	53 d	54 d	M
0	2946	3030	3116	3203	3292	3382	3474	3569	3665	3765	3865	0
1	47	31	17	04	93	84	76	70	67	67	67	1
2	49	33	18	06	95	85	78	73	69	69	69	2
3	50	34	20	07	96	87	79	74	70	70	70	3
4	51	36	21	09	98	88	81	75	72	72	72	4
5	53	37	23	10	99	90	82	77	73	73	73	5
6	54	38	24	12	3301	91	84	78	75	74	75	6
7	56	40	26	13	02	93	85	80	77	75	77	7
8	57	41	27	14	04	94	87	81	78	77	78	8
9	58	42	29	16	05	96	89	83	80	78	80	9
10	2900	3044	3130	3217	3307	3397	3490	3585	3682	3780	3882	10
11	61	46	31	19	08	99	92	86	83	82	83	11
12	63	47	33	20	10	3400	93	88	85	84	85	12
13	64	48	34	22	12	02	95	90	87	85	87	13
14	65	50	36	23	13	03	96	91	88	87	89	14
15	67	51	37	25	14	05	98	93	90	89	90	15
16	68	53	39	26	16	07	99	94	91	91	92	16
17	69	54	40	28	17	08	3501	96	93	92	94	17
18	71	55	42	29	19	10	03	98	95	94	95	18
19	72	57	43	31	20	11	04	99	96	96	97	19
20	2974	3058	3144	3232	3322	3413	3505	3600	3698	3797	3899	20
21	75	60	46	33	23	14	07	02	3700	99	3901	21
22	76	61	47	34	25	16	09	04	01	3801	02	22
23	78	63	49	35	26	17	10	05	03	02	04	23
24	79	64	50	38	28	19	12	07	05	04	06	24
25	81	65	52	40	29	20	14	09	06	06	07	25
26	82	67	53	41	31	22	15	10	08	07	09	26
27	83	68	55	42	32	23	17	12	09	09	11	27
28	85	70	56	44	34	25	18	14	11	11	13	28
29	86	71	57	45	35	27	20	15	13	12	14	29
30	2988	3073	3159	3247	3337	3428	3521	3617	3714	3814	3916	30
31	89	74	60	48	38	30	23	18	16	16	18	31
32	90	75	62	50	40	31	25	20	18	17	20	32
33	92	77	63	51	41	33	26	22	19	19	21	33
34	93	78	65	53	43	34	28	23	21	21	23	34
35	95	80	66	54	44	36	29	25	23	22	25	35
36	96	81	68	56	46	37	31	26	24	24	26	36
37	98	83	69	57	47	39	32	28	26	26	28	37
38	99	84	71	59	49	40	34	30	28	27	30	38
39	3000	85	72	60	50	42	36	31	29	29	32	39
40	3002	3087	3173	3262	3352	3443	3537	3633	3731	3831	3933	40
41	03	88	75	63	53	45	39	35	32	33	35	41
42	05	90	76	65	55	47	40	36	34	34	37	42
43	06	91	78	66	56	48	42	38	36	36	39	43
44	07	93	79	68	58	49	43	39	38	38	40	44
45	09	94	81	69	59	51	45	41	39	39	42	45
46	10	95	82	71	61	53	47	43	41	41	44	46
47	12	97	84	72	62	54	48	44	43	43	45	47
48	13	98	85	74	64	56	50	46	44	44	47	48
49	14	3100	87	75	65	57	51	48	46	46	49	49
50	3016	3101	3188	3277	3367	3459	3553	3649	3747	3848	3951	50
51	17	03	90	78	68	61	55	51	49	49	52	51
52	19	04	91	80	70	62	56	52	50	51	54	52
53	20	05	92	81	71	64	58	54	51	53	56	53
54	22	07	94	83	73	65	59	56	54	55	58	54
55	23	08	95	84	74	67	61	57	56	56	59	55
56	24	10	97	86	76	68	62	59	57	58	61	56
57	26	11	98	87	78	70	64	60	59	60	63	57
58	27	13	3200	89	79	71	66	62	60	61	65	58
59	29	14	01	90	81	73	67	64	62	63	66	59

M.	55 d	56 d	57 d	58 d	59 d	60 d	61 d	62 d	63 d	64 d	65 d	M.
0	3968	4074	4183	4294	4409	4528	4649	4775	4905	5040	5179	0
1	70	76	85	56	11	30	52	77	07	42	82	1
2	72	77	86	98	13	32	54	80	10	44	84	2
3	73	79	88	4300	15	34	56	82	12	47	86	3
4	75	81	90	02	17	36	58	84	14	49	89	4
5	77	83	92	04	19	38	60	86	16	51	91	5
6	78	85	94	06	21	40	62	88	19	53	93	6
7	80	87	96	08	23	42	64	90	21	56	96	7
8	82	88	97	10	25	44	66	92	23	58	98	8
9	83	90	99	12	27	46	68	95	25	60	5201	9
10	3986	4052	4201	4313	4429	4548	4670	4797	4927	5063	5203	10
11	87	94	03	15	31	50	72	99	30	65	05	11
12	89	95	05	17	33	52	74	4801	32	67	08	12
13	91	97	07	19	35	54	76	03	34	70	10	13
14	92	99	09	21	37	56	78	05	36	72	12	14
15	94	4100	10	23	39	58	81	07	38	74	15	15
16	96	01	12	25	41	60	83	10	41	76	17	16
17	98	03	14	27	43	62	85	12	43	79	20	17
18	4000	06	16	29	44	64	87	14	45	81	22	18
19	01	08	18	31	46	66	89	16	47	83	24	19
20	4003	4110	4220	4332	4448	4568	4691	4818	4950	5086	5227	20
21	05	12	22	34	50	70	92	20	52	88	29	21
22	06	14	23	36	52	72	95	22	54	90	31	22
23	08	15	25	38	54	74	97	25	56	93	34	23
24	10	17	27	40	56	76	99	27	59	95	36	24
25	12	19	29	42	58	78	4701	29	61	97	39	25
26	14	21	32	44	60	80	04	31	63	5100	41	26
27	15	23	33	46	62	82	06	33	65	02	44	27
28	17	24	35	48	64	84	08	35	67	04	46	28
29	19	26	36	50	66	86	10	38	70	07	48	29
30	4021	4128	4238	4352	4468	4588	4712	4840	4972	5109	5251	30
31	22	30	40	53	70	50	14	42	74	11	53	31
32	24	32	44	55	72	92	16	44	76	14	56	32
33	26	33	45	57	74	94	18	46	79	16	58	33
34	28	35	46	59	76	96	20	48	81	18	61	34
35	30	37	48	61	78	98	22	50	83	20	63	35
36	31	39	49	63	80	4000	24	53	85	23	65	36
37	33	41	51	65	82	03	27	55	88	25	68	37
38	35	43	53	67	84	04	29	57	90	27	70	38
39	37	44	55	69	86	06	31	59	92	30	73	39
40	4038	4146	4257	4371	4488	4608	4733	4861	4994	5132	5275	40
41	40	48	59	73	50	10	35	64	97	34	78	41
42	42	50	61	75	92	13	37	66	99	37	80	42
43	44	52	63	77	94	15	39	68	5001	39	83	43
44	46	54	64	78	56	17	41	70	03	42	85	44
45	47	55	66	80	98	19	43	72	06	44	87	45
46	49	57	68	82	4500	21	46	75	08	46	90	46
47	51	59	70	84	02	23	48	77	10	49	92	47
48	52	61	72	86	04	25	50	80	12	51	95	48
49	54	63	74	88	06	27	52	81	13	53	97	49
50	4056	4164	4276	4390	4508	4629	4754	4883	5017	5156	5299	50
51	58	66	78	52	10	31	56	85	20	58	5302	51
52	60	68	79	94	12	33	58	88	22	60	04	52
53	62	70	81	56	14	35	60	90	24	63	07	53
54	63	72	83	58	16	37	63	92	26	65	09	54
55	65	74	85	4400	18	39	65	94	28	67	12	55
56	67	75	87	02	20	41	67	97	31	70	14	56
57	69	77	89	04	22	43	69	99	33	72	17	57
58	70	79	91	05	24	45	71	4901	35	74	19	58

M	66 d	67 d	68 d	69 d	70 d	71 d	72 d	73 d	74 d	75 d	76 d	M
0	5324	5474	5631	5795	5967	6149	6336	5535	6747	6971	7215	0
1	26	78	34	98	70	50	39	39	50	75	20	1
2	29	80	37	5801	72	53	42	42	55	79	24	2
3	31	82	39	04	75	56	45	46	58	83	28	3
4	34	85	42	06	78	59	49	49	61	87	32	4
5	36	87	45	09	81	62	52	52	65	91	36	5
6	39	50	47	12	84	65	55	56	69	95	40	6
7	41	92	50	15	87	68	58	59	72	99	45	7
8	44	95	53	18	90	71	62	65	76	7003	49	8
9	46	98	55	20	93	74	65	68	78	06	53	9
10	5349	5500	5658	5823	5996	6177	6368	6570	6783	7010	7255	10
11	51	03	61	26	99	80	71	73	87	14	57	11
12	54	05	64	29	6002	83	75	77	91	18	61	12
13	56	08	66	32	05	87	78	80	94	22	65	13
14	59	11	69	34	08	90	81	84	98	26	70	14
15	61	13	72	37	11	93	85	87	6802	30	74	15
16	64	16	74	40	14	96	88	90	05	34	78	16
17	66	18	77	43	17	99	91	94	09	38	82	17
18	67	21	80	46	20	6202	94	97	13	42	87	18
19	71	23	82	49	23	05	98	6601	16	46	91	19
20	5373	5526	5685	5851	6026	6208	6401	6605	6820	7050	7295	20
21	76	29	88	54	29	12	04	08	24	54	99	21
22	78	31	91	57	32	15	08	11	27	58	7303	22
23	81	34	93	60	34	18	11	15	31	61	08	23
24	83	37	96	63	38	21	14	18	35	65	12	24
25	86	39	99	66	40	24	18	22	39	69	16	25
26	88	42	5701	68	43	27	21	25	42	73	21	26
27	91	44	04	72	46	30	24	29	46	77	25	27
28	93	47	07	74	49	34	27	32	50	81	29	28
29	96	49	10	77	52	37	31	36	54	85	33	29
30	5398	5552	5712	5880	6055	6240	6434	6639	6857	7089	7338	30
31	5401	55	15	83	58	43	37	43	61	93	42	31
32	03	57	18	86	61	46	41	47	65	97	46	32
33	06	60	21	88	64	49	44	51	69	7101	50	33
34	09	63	23	91	67	52	47	54	72	05	55	34
35	11	65	26	94	70	56	51	57	76	09	59	35
36	14	68	29	97	73	59	54	61	80	13	63	36
37	16	70	32	5900	76	62	57	64	84	17	68	37
38	19	73	34	03	79	65	61	68	87	21	72	38
39	21	76	37	06	82	68	64	71	91	26	76	39
40	5424	5578	5740	5909	6085	6271	6468	6675	6895	7130	7381	40
41	26	81	42	11	89	75	71	78	99	34	85	41
42	29	84	45	14	92	78	74	82	6903	38	89	42
43	31	86	48	17	95	81	78	86	06	42	94	43
44	34	89	51	20	98	84	81	89	10	46	98	44
45	36	92	54	23	6101	87	84	93	14	50	7403	45
46	39	94	56	26	04	91	88	96	18	54	07	46
47	41	97	59	29	07	94	91	6700	22	58	11	47
48	44	99	62	32	10	97	94	03	25	62	16	48
49	46	5602	65	35	13	6300	98	07	29	66	20	49
50	5449	5605	5767	5937	6116	6303	6501	6711	6933	7170	7424	50
51	54	07	70	40	20	07	05	14	37	74	29	51
52	56	10	73	43	22	10	08	18	41	78	33	52
53	58	13	76	46	25	13	11	21	44	82	38	53
54	59	15	78	49	28	16	15	25	48	87	42	54
55	62	18	81	52	31	19	18	29	52	91	46	55
56	64	21	84	55	34	23	22	32	56	95	51	56
57	67	23	87	58	37	26	25	36	60	99	55	57
58	69	26	90	61	40	29	28	39	64	7203	59	58
59	72	29	92	64	43	32	32	42	68	07	64	59

M	77 d	78 d	79 d	80 d	81 d	82 d	83 d	84 d	85 d	M
0	7469	7746	8047	8377	8741	9148	9609	10148	10770	0
1	73	51	53	83	48	55	17	150	781	1
2	78	56	58	89	54	63	25	160	793	2
3	82	61	63	95	61	70	34	170	804	3
4	86	65	69	8400	67	77	42	179	816	4
5	91	70	74	06	74	85	50	189	827	5
6	95	75	79	12	80	92	59	199	839	6
7	7500	80	84	18	87	99	67	209	851	7
8	04	85	90	24	93	9206	73	218	863	8
9	09	90	95	30	99	14	84	228	875	9
10	7513	7795	8100	8435	8806	9221	9692	10238	10886	10
11	18	99	06	41	13	28	9701	248	899	11
12	22	7804	11	47	19	36	09	258	910	12
13	27	09	16	53	26	43	18	268	922	13
14	31	14	22	59	32	50	26	278	934	14
15	36	19	27	65	39	58	35	288	946	15
16	40	24	32	71	45	65	43	298	958	16
17	45	29	38	77	52	73	52	303	971	17
18	50	34	43	83	55	80	60	318	983	18
19	54	39	49	89	65	88	69	328	995	19
20	7559	7844	8154	8494	8872	9295	9777	10338	11007	20
21	63	49	59	8500	78	9303	86	348	020	21
22	68	54	65	06	85	10	95	358	032	22
23	72	59	70	12	92	18	9803	368	047	23
24	77	64	76	18	98	25	12	378	058	24
25	82	69	81	24	8905	33	21	389	070	25
26	86	74	87	30	12	40	30	399	082	26
27	91	79	92	36	19	48	38	410	095	27
28	95	84	98	42	25	56	47	420	107	28
29	7600	89	8203	49	32	63	56	430	120	29
30	7605	7894	8208	8555	8939	9371	9865	10441	11133	30
31	09	99	14	61	46	79	74	451	146	31
32	14	7904	19	67	52	86	82	462	158	32
33	19	09	25	73	59	94	91	472	171	33
34	23	14	31	79	66	9402	9900	483	184	34
35	28	19	36	85	73	10	09	494	197	35
36	32	24	42	91	80	17	18	504	210	36
37	37	29	47	97	87	25	27	515	223	37
38	42	34	53	8603	93	33	36	526	236	38
39	46	39	58	10	9000	41	45	536	258	39
40	7651	7944	8264	8616	9007	9449	9954	10547	11263	40
41	56	49	69	22	14	56	63	558	276	41
42	61	54	75	28	21	64	73	569	289	42
43	65	59	80	34	28	72	82	579	303	43
44	70	65	88	41	35	80	92	590	316	44
45	75	70	92	47	42	88	10009	601	330	45
46	79	75	97	53	49	96	009	612	343	46
47	84	80	8303	59	56	9504	018	623	357	47
48	89	85	09	65	63	12	028	634	371	48
49	94	90	15	72	70	20	037	645	384	49
50	7698	7995	8320	8678	9077	9528	10046	10656	11398	50
51	7703	8001	26	84	84	36	056	668	412	51
52	08	06	31	91	91	44	065	679	426	52
53	13	11	37	97	98	52	074	690	440	53
54	17	16	43	8703	9105	60	084	701	464	54
55	22	21	49	10	12	68	093	713	468	55
56	27	27	54	16	20	76	103	724	482	56
57	32	32	60	22	27	85	112	735	496	57
58	37	37	66	29	34	93	122	747	510	58
59	41	42	75	35	41	9601	131	758	525	59

M	86 d	87 d	88 d	89 d	M
0	11539	12531	13920	16317	0
1	553	540	949	276	1
2	568	559	978	435	2
3	582	579	14007	495	3
4	597	598	037	557	4
5	611	618	067	619	5
6	626	638	097	683	6
7	641	658	127	748	7
8	656	678	158	814	8
9	671	698	189	881	9
10	11686	12718	14220	16950	10
11	701	738	252	17020	11
12	716	759	284	092	12
13	731	779	316	165	13
14	746	800	348	240	14
15	761	821	381	310	15
16	777	842	414	394	16
17	792	863	448	474	17
18	808	884	481	556	18
19	823	906	515	640	19
20	11839	12927	14550	17726	20
21	855	949	584	814	21
22	870	970	619	904	22
23	886	992	655	997	23
24	902	13014	691	18093	24
25	918	037	727	191	25
26	934	059	764	292	26
27	950	081	800	396	27
28	967	104	838	503	28
29	983	127	876	615	29
30	11999	13150	14914	18729	30
31	12016	172	952	848	31
32	032	196	992	971	32
33	049	219	15031	19098	33
34	066	243	071	230	34
35	086	267	111	368	35
36	099	294	152	511	36
37	116	315	194	660	37
38	133	339	236	817	38
39	150	363	278	980	39
40	12167	13388	15321	20152	40
41	185	413	365	333	41
42	202	437	409	524	42
43	220	463	453	726	43
44	237	488	499	941	44
45	255	513	545	21170	45
46	273	539	591	416	46
47	290	565	638	680	47
48	308	591	686	967	48
49	326	617	734	22279	49
50	12344	13643	15783	22623	50
51	363	670	833	23005	51
52	381	697	884	23435	52
53	399	724	935	23926	53
54	408	751	987	24499	54
55	426	779	16040	25786	55
56	445	807	094	26046	56
57	464	834	148	27192	57
58	483	863	204	28911	58
59	502	891	260	32348	59

Neceſſary

TABLES

Of the SUN's

DECLINATION,

AND

Latitude and Longitude of Places;

WITH

A TABLE of the Magnitudes, Right Aſcenſions and Declinations of ſome of the Principal

FIXED STARS;

ALSO,

A TABLE

OF THE

Sun's Right Aſcenſion, &c.

A Table of the Sun's Declination. First after Leap-Year, 1757, 1761, 1765, 1769, 1773.

Days	Jan.		Feb.		March		April		May		June	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	23	00	16	58	07	24	04	43	15	13	22	08
2	22	54	16	41	07	01	05	06	15	31	22	16
3	22	48	16	23	06	38	05	29	15	48	22	23
4	22	42	16	05	06	15	05	52	16	05	22	30
5	22	35	15	46	05	52	06	15	16	23	22	37
6	22	28	15	28	05	29	06	37	16	40	22	43
7	22	20	15	10	05	06	07	00	16	56	22	49
8	22	12	14	51	04	42	07	22	17	13	22	55
9	22	04	14	31	04	19	07	45	17	29	23	00
10	21	55	14	12	03	55	08	07	17	44	23	05
11	21	45	13	52	03	32	08	29	18	00	23	09
12	21	35	13	32	03	08	08	51	18	15	23	13
13	21	25	13	12	02	44	09	13	18	30	23	16
14	21	14	12	51	02	21	09	34	18	44	23	19
15	21	03	12	31	01	57	09	55	18	59	23	22
16	20	52	12	10	01	33	10	17	19	13	23	24
17	20	40	11	49	01	10	10	38	19	26	23	26
18	20	28	11	28	00	46	10	59	19	39	23	27
19	20	15	11	06	00	22	11	20	19	52	23	28
20	20	02	10	45	Nor.	01	11	40	20	05	23	29
21	19	49	10	23	00	25	12	01	20	17	23	29
22	19	35	10	01	00	49	12	21	20	29	23	29
23	19	21	09	39	01	12	12	41	20	41	23	28
24	19	06	09	17	01	36	13	01	20	52	23	27
25	18	51	08	55	02	00	13	20	21	03	23	26
26	18	36	08	32	02	23	13	39	21	13	23	24
27	18	21	08	10	02	47	13	59	21	23	23	21
28	18	05	07	47	03	10	14	18	21	33	23	19
29	17	49			03	33	14	36	21	42	23	15
30	17	32			03	57	14	55	21	51	23	12
31	17	15			04	20			22	00		

A Table of the Sun's Declination.

First after Leap-Year, 1757, 1761, 1765, 1769, 1773.

Days	July		August		Sept.		Octob.		Nov.		Dec.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	23	08	17	59	08	10	03	20	14	36	21	55
2	23	04	17	44	07	49	03	44	14	55	22	04
3	22	59	17	28	07	27	04	07	15	14	22	13
4	22	54	17	12	07	05	04	30	15	33	22	21
5	22	48	16	56	06	42	04	54	15	51	22	29
6	22	42	16	39	06	20	05	17	16	09	22	36
7	22	36	16	22	05	57	05	40	16	27	22	43
8	22	29	16	05	05	35	06	03	16	44	22	49
9	22	22	15	48	05	12	06	26	17	01	22	55
10	22	15	15	31	04	49	06	48	17	18	23	00
11	22	07	15	13	04	26	07	11	17	35	23	05
12	21	58	14	55	04	03	07	34	17	51	23	10
13	21	50	14	36	03	40	07	56	18	07	23	14
14	21	41	14	18	03	17	08	19	18	23	23	17
15	21	31	13	59	02	54	08	41	18	38	23	20
16	21	22	13	40	02	31	09	03	18	53	23	23
17	21	11	13	21	02	07	09	25	19	08	23	25
18	21	01	13	02	01	44	09	47	19	23	23	27
19	20	50	12	42	01	21	10	09	19	37	23	28
20	20	38	12	22	00	57	10	31	19	50	23	29
21	20	27	12	02	00	34	10	52	20	04	23	29
22	20	15	11	42	00	11	11	13	20	17	23	29
23	20	03	11	22	Sou.	13	11	34	20	29	23	28
24	19	51	11	01	00	36	11	55	20	41	23	27
25	19	38	10	40	01	00	12	16	20	53	23	25
26	19	25	10	19	01	23	12	37	21	04	23	23
27	19	11	09	58	01	46	12	57	21	15	23	21
28	18	57	09	37	02	10	13	17	21	26	23	18
29	18	43	09	16	02	33	13	37	21	36	23	14
30	18	29	08	54	02	56	13	57	21	46	23	10
31	18	14	08	32			14	17			23	06

A Table of the Sun's Declination.

Second after Leap-Year, 1758, 1762, 1766, 1770, 1774.

Days	Jan.		Feb.		March		April		May		June	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	23	01	17	02	07	30	04	37	15	08	22	06
2	22	55	16	45	07	07	05	00	15	26	22	14
3	22	49	16	27	06	44	05	23	15	44	22	22
4	22	43	16	10	06	21	05	46	16	01	22	29
5	22	37	15	52	05	58	06	09	16	18	22	36
6	22	30	15	33	05	34	06	32	16	35	22	43
7	22	23	15	14	05	10	06	54	16	52	22	49
8	22	15	14	55	04	46	07	17	17	09	22	54
9	22	06	14	36	04	23	07	39	17	25	22	59
10	21	57	14	16	04	00	08	01	17	41	23	04
11	21	48	13	57	03	37	08	23	17	56	23	08
12	21	38	13	37	03	14	08	45	18	11	23	12
13	21	28	13	17	02	50	09	07	18	26	23	15
14	21	17	12	57	02	26	09	29	18	41	23	18
15	21	06	12	36	02	03	09	50	18	56	23	21
16	20	55	12	15	01	40	10	11	19	10	23	23
17	20	43	11	54	01	16	10	32	19	24	23	25
18	20	31	11	33	00	52	10	53	19	37	23	27
19	20	18	11	11	00	28	11	14	19	50	23	28
20	20	05	10	49	00	05	11	35	20	02	23	29
21	19	52	10	28	Nor.	19	11	55	20	14	23	29
22	19	38	10	07	00	43	12	15	20	26	23	29
23	19	24	09	45	01	06	12	35	20	38	23	28
24	19	10	09	23	01	30	12	55	20	50	23	27
25	18	55	09	00	01	53	13	15	21	01	23	26
26	18	40	08	38	02	17	13	34	21	11	23	24
27	18	25	08	15	02	40	13	53	21	21	23	21
28	18	09	07	53	03	04	14	12	21	31	23	18
29	17	53			03	27	14	31	21	40	23	15
30	17	37			03	51	14	50	21	49	23	12
31	17	19			04	14			21	58		

A Table of the Sun's Declination.

Second after Leap-Year, 1758, 1762, 1766, 1770, 1774.

Days	July		Auguſt		Sept.		Octob.		Nov.		Dec.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	23	08	18	02	08	15	03	15	14	31	21	54
2	23	04	17	47	07	54	03	38	14	50	22	03
3	22	59	17	31	07	32	04	02	15	09	22	12
4	22	54	17	15	07	10	04	25	15	28	22	20
5	22	49	16	59	06	47	04	48	15	47	22	27
6	22	43	16	43	06	25	05	11	16	05	22	34
7	22	37	16	27	06	02	05	34	16	23	22	41
8	22	30	16	10	05	39	05	57	16	41	22	48
9	22	23	15	53	05	17	06	20	16	58	22	54
10	22	16	15	35	04	54	06	43	17	15	23	00
11	22	08	15	17	04	32	07	05	17	32	23	05
12	22	00	14	59	04	09	07	28	17	48	23	10
13	21	52	14	41	03	46	07	50	18	04	23	14
14	21	43	14	23	03	23	08	13	18	20	23	17
15	21	34	14	04	03	00	08	35	18	35	23	20
16	21	24	13	45	02	37	08	57	18	50	23	23
17	21	14	13	26	02	14	09	19	19	05	23	25
18	21	04	13	07	01	50	09	41	19	19	23	27
19	20	53	12	47	01	27	10	03	19	33	23	28
20	20	42	12	27	01	03	10	25	19	47	23	29
21	20	30	12	07	00	39	10	47	20	00	23	29
22	20	18	11	47	00	16	11	08	20	13	23	29
23	20	06	11	27	Sou.	08	11	29	20	26	23	28
24	19	54	11	06	00	31	11	50	20	38	23	27
25	19	41	10	45	00	54	12	11	20	50	23	25
26	19	28	10	24	01	17	12	32	21	02	23	24
27	19	15	10	03	01	40	12	52	21	13	23	21
28	19	01	09	42	02	04	13	11	21	24	23	18
29	18	47	09	20	02	28	13	32	21	34	23	15
30	18	33	08	58	02	52	13	52	21	44	23	11
31	18	18	08	36			14	12			23	17

A Table of the Sun's Declination.

Third after Leap-Year 1759, 1763, 1767, 1771, 1775.

Days	Jan.		Feb		March		April		May		June	
	D	M	D	M	D	M	D	M	D	M	D	M
1	23	02	17	06	07	36	04	31	15	04	22	04
2	22	57	16	49	07	13	04	54	15	22	22	12
3	22	51	16	31	06	50	05	17	15	40	22	20
4	22	45	16	14	06	27	05	40	15	58	22	27
5	22	39	15	56	06	03	06	03	16	15	22	34
6	22	32	15	38	05	40	06	26	16	32	22	40
7	22	24	15	19	05	17	06	48	16	49	22	46
8	22	16	15	00	04	54	07	10	17	05	22	52
9	22	08	14	41	04	30	07	33	17	21	22	57
10	21	59	14	22	04	07	07	56	17	37	23	02
11	21	50	14	02	03	43	08	18	17	52	23	07
12	21	40	13	42	03	20	08	40	18	07	23	11
13	21	30	13	22	02	56	09	02	18	22	23	14
14	21	20	13	02	02	32	09	23	18	37	23	18
15	21	09	12	42	02	08	09	45	18	52	23	21
16	20	58	12	21	01	45	10	07	19	06	23	23
17	20	46	12	00	01	21	10	28	19	20	23	25
18	20	34	11	39	00	57	10	49	19	34	23	27
19	20	21	11	18	00	34	11	10	19	47	23	28
20	20	09	10	56	00	10	11	30	20	00	23	29
21	19	56	10	34	Nor.	14	11	50	20	12	23	29
22	19	42	10	12	00	37	12	10	20	24	23	29
23	19	28	09	50	01	01	12	30	20	36	23	28
24	19	14	09	28	01	24	12	50	20	47	23	28
25	18	59	09	06	01	48	13	10	20	58	23	27
26	18	44	08	44	02	12	13	29	21	09	23	25
27	18	29	08	21	02	35	13	48	21	19	23	23
28	18	13	07	58	02	58	14	07	21	29	23	20
29	17	56			03	22	14	26	21	38	23	17
30	17	40			03	45	14	45	21	47	23	14
31	17	23			04	08			21	56		

A Table of the Sun's Declination.

Third after Leap-Year, 1759, 1763, 1767, 1771, 1775.

Days	July		Auguſt		Sept.		Octob.		Nov.		Dec.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	23	09	18	06	08	22	03	08	14	26	21	52
2	23	05	17	51	08	00	03	32	14	46	22	01
3	23	01	17	35	07	38	03	55	15	05	22	09
4	22	56	17	19	07	16	04	18	15	24	22	17
5	22	50	17	04	06	54	04	41	15	42	22	25
6	22	44	16	48	06	32	05	04	16	00	22	32
7	22	38	16	31	06	09	05	27	16	18	22	39
8	22	32	16	14	05	46	05	50	16	36	22	45
9	22	25	15	57	05	23	06	13	16	54	22	51
10	22	18	15	39	05	00	06	36	17	11	22	57
11	22	10	15	21	04	38	06	59	17	28	23	02
12	22	02	15	03	04	15	07	22	17	44	23	07
13	21	54	14	45	03	52	07	44	18	00	23	11
14	21	45	14	27	03	29	08	07	18	16	23	15
15	21	35	14	09	03	06	08	30	18	32	23	18
16	21	26	13	50	02	43	08	52	18	47	23	21
17	21	16	13	31	02	19	09	14	19	02	23	24
18	21	05	13	11	01	56	09	36	19	16	23	26
19	20	54	12	51	01	33	09	58	19	30	23	27
20	20	43	12	32	01	09	10	20	19	44	23	28
21	20	32	12	12	00	45	10	42	19	57	23	29
22	20	21	11	52	00	22	11	04	20	10	23	29
23	20	10	11	32	Sou.	01	11	25	20	23	23	29
24	19	58	11	12	00	25	11	45	20	35	23	28
25	19	45	10	51	00	48	12	05	20	47	23	26
26	19	31	10	30	01	12	12	26	20	59	23	24
27	19	18	10	09	01	35	12	47	21	10	23	22
28	19	04	09	48	01	59	13	07	21	21	23	19
29	18	50	09	27	02	22	13	27	21	31	23	16
30	18	36	09	06	02	45	13	47	21	42	23	13
31	18	21	08	43			14	07			23	09

A Table of the Sun's Declination.

Leap-Year, 1760, 1764, 1768, 1772, 1776.

Days	Jan.		Feb		March		April		May		June	
	D	M	D	M	D	M	D	M	D	M	D	M
1	23	03	17	11	07	18	04	49	15	17	22	10
2	22	58	16	54	06	55	05	12	15	34	22	18
3	22	52	16	36	06	32	05	35	15	52	22	25
4	22	46	16	18	06	09	05	57	16	10	22	32
5	22	40	16	00	05	46	06	20	16	27	22	39
6	22	33	15	42	05	23	06	43	16	44	22	45
7	22	26	15	24	04	59	07	05	17	00	22	51
8	22	18	15	05	04	36	07	27	17	17	22	56
9	22	10	14	46	04	13	07	50	17	33	23	01
10	22	01	14	27	03	49	08	12	17	48	23	06
11	21	52	14	07	03	26	08	34	18	04	23	10
12	21	42	13	47	03	02	08	56	18	19	23	14
13	21	33	13	27	02	38	09	18	18	34	23	17
14	21	23	13	07	02	15	09	39	18	48	23	20
15	21	12	12	46	01	51	10	00	19	02	23	22
16	21	01	12	26	01	28	10	21	19	16	23	24
17	20	49	12	05	01	04	10	42	19	29	23	26
18	20	37	11	43	00	40	11	03	19	42	23	28
19	20	25	11	22	00	16	11	24	19	55	23	28
20	20	12	11	01	Nor	07	11	45	20	08	23	29
21	19	59	10	40	00	31	12	05	20	20	23	29
22	19	45	10	18	00	55	12	26	20	32	23	29
23	19	31	09	56	01	18	12	45	20	43	23	28
24	19	17	09	34	01	41	13	05	20	54	23	27
25	19	03	09	12	02	05	13	25	21	05	23	25
26	18	48	08	49	02	29	13	44	21	15	23	23
27	18	32	08	27	02	52	14	03	21	25	23	20
28	18	17	08	04	03	15	14	22	21	35	23	18
29	18	01	07	41	03	39	14	41	21	44	23	15
30	17	45			04	02	14	59	21	53	23	11
31	17	28			04	25			22	02		

A Table of the Sun's Declination.

Leap-Year, 1760, 1764, 1768, 1772, 1776.

Days	July		Auguſt		Sept.		Octob.		Nov.		Dec.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	23	07	17	55	08	05	03	27	14	41	21	58
2	23	03	17	40	07	43	03	50	15	00	22	07
3	22	58	17	24	07	21	04	13	15	19	22	15
4	22	52	17	08	06	59	04	36	15	37	22	23
5	22	47	16	52	06	37	04	59	15	55	22	30
6	22	41	16	35	06	14	05	22	16	13	22	37
7	22	34	16	18	05	52	05	45	16	31	22	44
8	22	27	16	01	05	29	06	08	16	49	22	50
9	22	20	15	44	05	06	06	31	17	06	22	56
10	22	13	15	26	04	44	06	54	17	23	23	01
11	22	05	15	08	04	21	07	17	17	39	23	06
12	21	56	14	51	03	57	07	39	17	55	23	11
13	21	47	14	33	03	34	08	02	18	11	23	15
14	21	38	14	14	03	11	08	24	18	27	23	18
15	21	29	13	55	02	48	08	47	18	42	23	21
16	21	19	13	36	02	25	09	09	18	57	23	23
17	21	09	13	16	02	02	09	31	19	12	23	25
18	20	58	12	57	01	38	09	53	19	26	23	27
19	20	47	12	37	01	15	10	14	19	40	23	28
20	20	36	12	17	00	52	10	36	19	54	23	29
21	20	25	11	57	00	29	10	57	20	07	23	29
22	20	13	11	37	00	05	11	19	20	20	23	29
23	20	00	11	17	Sou.	19	11	40	20	32	23	28
24	19	48	10	56	00	42	12	01	20	44	23	27
25	19	35	10	35	01	06	12	21	20	56	23	25
26	19	21	10	14	01	29	12	42	21	07	23	22
27	19	08	09	53	01	53	13	02	21	18	23	19
28	18	54	09	32	02	16	13	22	21	29	23	16
29	18	40	09	11	02	39	13	42	21	39	23	13
30	18	25	08	49	03	03	14	02	21	48	23	09
31	18	10	08	27			14	22			23	05

A TABLE of the Latitude and Longitude of the Principal Harbours, Headlands and Iſlands in the WORLD: Corrected by the lateſt and beſt Obſervations: Accounting the Longitude from the Meridian of LONDON.

Note, *When the Latitude and Longitude of an Iſland is given, the middle of the Iſland is meant, except ſome particular Parts of it be expreſſed.*

	Places Names.	Latitude N. or S. D.	M.	Longitude E. or W. D.	M.	
The Coaſt of *England.*	*Berwick*	55	50	1	39	W
	Newcaſtle	54	58	1	30	W
	Stockton	54	33	1	25	W
	Flambro'-head	54	8	1	10	W
	Spurn	53	35	0	13	E
	Yarmouth	52	45	1	40	E
	Orfordneſs	52	20	1	10	E
	LONDON	51	32	0	0	
	North Foreland	51	28	1	10	E
	South Foreland	51	12	1	20	E
	Beachy	50	48	0	25	E
	Dunnoſe Iſle of Wight	50	38	1	23	
	Portland	50	30	2	30	
	Topſham	50	37	3	25	
	Start Point	50	9	3	45	
	Lizard	49	55	5	14	
	Land's-end	50	6	6	0	
	St. Mary's Scilly	49	57	6	45	
	Hartland Point	51	6	4	35	
	Lundy Iſle	51	20	4	40	
	Milford	51	44	4	45	
	Briſtol	51	32	2	35	

North Latitude. Weſt Longitude.

St.

	Places Names.	Latitude N. or S. D.	M.		Longitude E. or W. D.	M.	
The Coaſt of *England.*	*St. David's Head*	51	55	North Latitude.	05	22	Weſt Longitude.
	Barſey Iſle	52	46		04	58	
	Holy Head	53	23		04	40	
	Liverpool	53	20		02	58	
	Iſle of Man S.W. End	53	58		04	41	
	White-haven	54	25		03	15	
	Carliſle	54	45		02	25	
The Coaſt of *Scotland.*	*Glaſgow*	55	53	North Latitude.	04	05	Weſt Longitude.
	North part of Sky Iſland	57	50		05	21	
	N. part of Lewis Iſland	58	20		07	15	
	St. Kilda	58	20		10	05	
	Farra Head	58	23		05	05	
	N.ermoſt Iſles of Orkney	59	13		03	30	
	Fair Iſle	59	30		03	20	
	Shetland South point	59	52		01	30	
	Buchaneſs	57	55		01	26	
	Aberdeen	57	24		01	37	
	Dundee	56	30		02	36	
	Edinburgh	55	57		02	46	
The Sea Coaſts about the Iſlands of *Iceland.*	*Grimes Hole or Genberman's Rock*	66	23	North Latitude.	20	50	Weſt Longitude.
	Gamart Iſles or Gille	65	48		27	30	
	Weſtmania Iſles	63	37		23	17	
	Rock Point	64	00		26	03	
	Snow Hill	65	11		27	14	
	Fair Foreland	65	40		26	17	
	Marza or Largerneſs	66	08		24	00	
	Grimſa Iſle	67	22		22	44	
	Lange Neſs	66	56		13	00	
	Scilly or Papey Iſland	64	50		12	10	
	Horn Bay	64	42		12	10	
	Merchants Foreland	63	52		19	06	
	Portland	64	02		21	05	

Dublin

	Places Names.	Latitude N. or S.		Longitude E. or W.	
		D.	M.	D.	M.
The Coaſt of *Ireland.*	*Dublin*	53	20	07	06
	Wexford	52	13	07	15
	Waterford	53	07	07	52
	Old Head of Kingſale	51	35	08	55
	Cork	51	49	09	30
	Cape Clear	51	10	10	30
	Cow and *Calf*	51	22	10	36
	Limrick	52	21	00	48
	Galway	53	10	10	03
	Sline-head	53	20	11	15
	Londonderry	54	55	08	00
	Belfaſt	54	36	06	50
The Coaſt of *Holland* and *Flanders.*	*Scaw*	57	26	10	10
	Helighland	54	28	08	35
	Hambrough	53	41	10	24
	Embden	53	05	08	00
	The Fly	53	18	05	35
	The Texel	53	10	04	59
	Amſterdam	51	21	04	51
	Rotterdam	51	55	04	21
	The Brill	51	56	04	10
	Oſtend	51	10	02	55
	Sluyce	51	19	03	50
	Calice	50	57	02	00
The Coaſt of *France* and *Portugal.*	*Bulloign*	50	45	01	35
	Diep	49	56	01	06
	Cape de Hague	49	46	02	06
	Caſkets	49	50	02	32
	Guernſey	49	36	02	40
	Morlaix	48	37	03	50
	Iſle Baſs	49	00	04	00
	Uſhant	48	30	05	05

North Latitude. West Longitude. East Longitude. East W. Longitude.

Breſt

Places Names.	Latitude N. or S.		Longitude E. or W.		
	D.	M.	D.	M.	
The Coaſt of *France* and *Portugal.*					
Breſt	48	23	04	42	
Penmark	47	48	04	15	
Bell-Iſle	47	20	03	10	
Nantz	47	14	01	49	
Iſland Dieu	46	40	02	15	
Iſland Ree	46	13	01	30	
Rochel	46	10	01	14	
Oleroon	46	00	00	34	
Bourdeaux	44	50	00	24	
Bilboa	43	30	03	00	
Cape Pinas	44	45	06	00	
Cape Ortegal	44	02	07	40	
Cape Finiſterre	43	06	10	00	
Port a Port	41	18	09	20	
Burlings	39	39	10	16	
Rock of Liſbon	38	54	10	20	
Sevil	37	37	06	36	
Cape St. Vincent	37	00	09	32	
Cadiz	36	16	07	00	
C. Trefalgar	36	10	06	30	
The Coaſt of the Main Continent within the *Straits.*					
Gibralter	36	11	05	43	W
Malaga	36	03	03	17	W
Cape de Gat	37	58	02	01	W
Cape Paul	37	25	00	22	
Alicant	38	54	00	10	
Cape Martin	39	00	00	28	
Tortoſa	40	54	01	14	
Barcelona	41	30	02	21	
Marſeilles	43	20	05	15	
Toulon	43	06	05	40	
Genoa	44	25	08	40	
Leghorn	43	10	10	29	
Civita Vechia	41	47	12	03	

North Latitude. — Weſt Longitude.

North Latitude. — Eaſt Longitude.

Rome

Places Names.	Latitude N. or S. D.	M.	Longitude E. or W. D.	M.
The Sea Coasts on the Main Continent within the *Straits.*				
Rome	41	51	12	28
Naples	41	05	14	28
Cape Spartavanto	38	00	16	58
Cape Callone	39	10	18	00
Gallipoli	40	08	18	39
Cape St. Maria	39	56	19	00
Ancona	43	31	14	40
Venice	45	18	13	10
Reguſa	40	40	20	00
La Valona	42	56	21	24
Lepanto	38	20	21	55
C. Matapan	36	35	22	20
C. St. Angelo	36	41	23	20
Cape Colona	37	30	25	24
Athens	38	00	24	29
Cape Marcelo S. P. of Negropont	38	00	25	45
Cape Monte Sancto	40	05	26	05
Gallipoli	40	30	27	58
Conſtantinople	41	07	30	00
Smyrna	38	30	27	27
Epheſus	37	54	27	15
Antiochetta	36	40	31	37
Scandaroon	36	00	35	58
Antiochia	35	54	39	20
Tripoli	34	40	35	50
Joppa	32	32	37	15
Cairo	30	05	34	20
Alexandria	31	07	30	40
Cape Ruſato	33	15	21	55
Cape Miſerato	32	43	16	23
Tripoli	32	55	13	00
Cape Bona	37	05	10	00
Bona	36	00	07	00

North Latitude. East Longitude.

Tunis

	Places Names.	Latitude N. or S.		Longitude E. or W.		
		D.	M.	D.	M.	
C. on the Main Continent within the *Straits.*	*Tunis*	36	50 North Latitude.	10	00	East
	Algier	36	40	03	05	
	Oran	35	46	01	05	
	Cape de Tres forcas	35	34	01	25	West
	Tetuan	35	28	05	52	
	Seuta	35	50	05	27	
	Tangier	35	55	06	14	
Iſlands within the *Straits.*	*Alboran*	36	10	00	30 W	
	Formentura	38	44	01	31	
	Yvica	39	05	01	30	
	Majorca City	39	48	02	49	
	Port Mahon Minorca	40	02	04	25	
	Gallitta	37	40	08	34	
	Sardinia South End	39	12	08	34	
	Corſica North End	24	57	09	45	
	Gorgona	43	34	09	38	
	Capria	43	06	09	40	
	Bilboa	42	44	10	05	East Longitude.
	Meſſina	38	22	16	25	
	Palermo	38	20	14	18	
	Maritimo	38	12	11	55	
	Syracuſe	37	15 North Latitude.	16	35	
	Cape Paſſero	36	48	16	04	
	Malta	36	10	14	49	
	Limoſa	36	20	14	41	
	Limpadoſa	35	58	14	05	
	Sematto	35	46	14	15	
	Corfu	39	45	20	42	
	Cephalonia	38	15	21	40	
	Zant	37	47	24	10	
	Madon or Morea	36	52	21	42	
	Lemnos	39	50	25	27	
	Scio	38	20	23	31	

Negra

	Places Names.	Latitude N. or S. D.	M.		Longitude E. or W. D.	M.	
Islands within the *Straits.*	*Negropont*	38	36	North Latitude.	25	42	East Longitude.
	Cape St. John W. End of Candy	35	20		23	27	
	Cape Solomon, E. End of Candy	35	25		26	31	
	Rhodes City	36	40		28	00	
	West End of Cyprus	35	21		31	35	
	East End of Cyprus	35	35		34	25	
The Coast of *Barbary* and *Guiney.*	*Cape Spartel*	35	46	North Latitude.	05	55	West Longitude
	Salle	33	43		06	30	
	Cape Cantin	32	16		09	20	
	Cape de Geer	30	04		10	10	
	Cape Non	28	52		11	30	
	Cape Bajador	26	12		14	30	
	Cape Olerado	23	41		15	50	
	Cape Blanco	20	35		16	55	
	Senegal	15	16		15	40	
	Cape de Verde	14	30		16	26	
	River Gambia	13	16		15	20	
	Serralion	08	36		12	15	
	Cape Monte	06	23		10	05	
	Monserado	06	05		09	20	
	River Sester	05	20		07	36	
	Cape Palmos	04	08		05	30	
	River St. Andrew	05	00		03	15	
	Jaque Jaque	04	16		02	30	
	Assene	04	15		01	00	
	Cape Three Points	04	13		00	45	E. Longitude.
	River Volto	05	40		03	30	
	River Formosa	07	00		07	40	
	Cape Formosa	04	40		08	00	
	New Callabar	04	12		10	25	
	Old Callabar	04	18		11	32	

River

	Places Names.	Latitude N. or S. D.	M.		Longitude E. or W. D.	M.	
The Coaſt of *Barbary* and *Guiney*.	*Saſmons River*	4	0	N	13	8	
	River Camarones	4	2	N	13	10	
	Iſland Fernandepo	2	40	N	13	40	
	Princes Iſland	1	50	N	12	20	
	River de Angra	0	49	N	13	15	
	Iſland Cabos	0	40		11	36	
	Iſland St. Thomas	0	0		11	0	East Longitude.
	Iſland St. Matthew	1	40		7	11	
	Iſland Aſcenſion	8	10	South Latitude.	1	45	
	Iſland Anabona	2	2		10	32	
	Lopas	4	2		12	20	
	River Congo	5	45		15	25	
	Angola	8	51		15	56	
	Cape Negro	16	8		14	46	
	Iſland St. Helena	16	2		16	10	
	Cape St. Thomas	23	10		14	23	
	Secos	28	56		15	32	
	Cape Bona Eſperance	34	25		17	25	
Weſtern Iſlands.	*Carvo*	40	5	North Latitude.	29	55	Weſt Longitude.
	Flores	39	40		29	50	
	Fyal	38	53		27	16	
	Pico	38	32		26	31	
	St George	38	56		26	10	
	Tercera	38	53		24	42	
	St. Michael	38	00		22	32	
	St. Maryes	37	00		22	17	
Canary Iſlands.	*Ferro*	28	0	N. Latitude.	18	12	W. Longitude.
	Palmo	28	50		18	0	
	Gomero	28	08		17	26	
	Tenariff	28	20		16	45	
	Madera Weſt-end	32	17		17	22	
	Porto Santo	32	50		15	50	

	Places Names.	Latitude N. or S. D.	M.		Longitude E. or W. D.	M.	
Canary Islands.	*Canaria*	27	56	N	15	30	W
	Fortaventura	27	54	N	13	24	W
	Lancerota	28	32	N	12	54	W
Cape de *Verde* Islands.	*St. Antonio*	17	10	North Latitude.	25	20	West Longitude.
	St. Vincent	16	55		25	10	
	St. Lucia	16	45		24	58	
	St. Nicholas	16	40		24	22	
	Brava	14	35		24	38	
	Fuogo	14	42		24	00	
	Java	15	20		23	10	
	Isle of May	15	16		22	12	
	Isle Sal	16	45		22	02	
	Bonavista	16	05		21	55	
Southern Islands.	*St. Matthews*	01	40	S	03	55	W
	Ascension	08	10	S	12	35	W
	St. Helena	16	06	S	05	40	W
	Fernandepo	02	35	N	11	55	E
	Princeps	01	25	N	11	00	E
	St. Thomas	00	00	—	09	58	E
	Annabona	01	22	S	09	28	E
Coasts of the Main Continent in the *East-Indies.*	*Cape Bona Esperance*	34	25	South Latitude.	17	25	East Longitude.
	Cape Lagullas	35	35		18	40	
	River St Lucia	30	25		30	15	
	Cape Corientes	23	52		35	35	
	Misambique	15	05		40	30	
	Cape Falso	09	00		38	50	
	Tongon	05	10		39	7	
	Mombasa	04	15		38	30	
	Melinde	03	00		40	0	
	River Lamas	01	00		40	13	
	River de Fugos	00	00		41	15	

Mag-

Places Names.	Latitude N. or S. D.	M.	Longitude E. or W. D.	M.
The Coaſt of the Main Continent in the *Eaſt-Indies.*				
Magadoxo	02	01	44	20
Cape Baſſos	04	00	49	50
Cape Gardaſoy	11	50	52	30
Cape Roſulgat	22	27	60	45
Cape Muca	26	56	57	10
Buſſera	30	00	49	05
Gambaroon	27	30	56	36
Surrat	21	08	73	25
Goa	15	22	74	37
Calecute	11	17	75	54
Cochin	09	58	76	45
Cape Comarine	07	50	78	25
Columba in Zeloan	07	07	80	05
Fort St. George	13	08	81	42
Dew Point	15	50	82	05
Viſegapatam	17	40	85	07
Pondy	18	45	85	50
Cape Palmiris	20	45	88	10
Ballaſore	21	00	88	20
Piply	21	15	88	30
Bengal	22	27	91	49
Cape Negrais	16	23	93	05
Malacca	02	21	101	20
Formoſa	01	55	101	40
Siam Entrance	13	10	101	01
Cambodia Entrance	10	30	105	20
Cape Avarilla	12	10	109	03
Cochin	18	25	103	58
Cantam	23	30	113	20
Amoy or Quemoy	24	35	116	55
Lampo	30	10	120	25
Iſland Chuſan	30	25	120	15
Nanquim	32	55	120	05

North Latitude. East Longitude.

Islands in the *East-Indies.*	Places Names.	Latitude N. or S. D.	M.		Longitude E. or W. D.	M.	
	Madagaſcer or S. Eaſt	26	00	South Latitude.	46	20	East Longitude.
	St. Lawrenes N. Eaſt	12	10		50	10	
	St. John de Liſbon	26	04		53	38	
	Mayetta	13	10		45	45	
	Mobilla	12	15		43	41	
	Comero	11	50		43	44	
	St. Juan de Nova	17	30		42	35	
	Mauritias	20	05		55	05	
	Digo Royes	19	45		61	35	
	Romiras de Caſte Limos	29	05		66	56	
	Amſterdam	39	50		74	24	
	St. Brandon	16	38		64	30	
	Digo Gratioſa	08	42		69	05	
	Quabella	03	49		52	39	
	Baſſos de Chagos	06	05		70	24	
	Yas de Digo Rays	00	00		72	05	
	Maldivia N. End	07	05		73	05	
	Maldivia S. End	01	00		76	15	
	Malique	09	00	North Latitude.	73	15	
	Saccatra	12	28		55	37	
	Abdeleur	12	10		54	23	
	C. Gallo in Zeloan	06	07		80	45	
	Yas de Amber	00	0		52	30	
	Andaman	13	0		91	25	
	Nicobar	7	5		92	55	
	Sumatra N. W. End	5	28		93	45	
	Virkins Iſland	2	22	South Latitude.	94	07	
	Naſſau Iſland	2	44		98	32	
	Bencola	3	50		101	13	
	Sumatra S.E. End	5	42		104	04	
	Engano	4	40		100	53	
	Selam	8	20		102	13	
	Princes Iſland	6	30		104	02	
	Buntam on Java	5	47		105	11	

Bata-

	Places Names.	Latitude N. or S.		Longitude E. or W.	
		D.	M.	D.	M.
Islands in the *East-Indies.*	*Batavia*	5	37 South Latitude.	106	27 West Longitude.
	Java E. End	8	35	112	27
	Straits of Sunda	5	52	104	18
	Banco S. End	3	25	106	37
	Borneo S. Point	4	14	112	52
	Bandy Isles	5	5	126	37
	Celebes South End	6	0	117	27
	Celebes North End	1	40	121	30
	Mindano W. Point	6	30	118	35
	Borneo N. Point	7	10	112	45
	Luconia S. Point	12	30 North Latitude.	120	50
	Luconia N.E. Point	18	35	119	5
	Anain W. Point	19	30	108	6
	Anain E. Point	19	55	111	16
	Formosa S. Point	22	00	119	30
	Formosa N. Point	35	32	120	25
	Piscadore Isles	23	30	117	35
	Islands Chusan	30	38	120	35
	Japan S.E. Point	39	50	135	15
	Japan S.W. Point	39	10	126	55
The Coast of *America* in the *South-Sea* from *Californ* to *Cape Horn.*	*Cape St. Sebastian*	42	40 North Latitude.	129	55 West Longitude.
	Cape St. Luca	23	25	111	56
	Cape Corientes	19	40	110	30
	Aquapulco	17	00	106	28
	Aquatulco	15	27	101	3
	Guatimala	14	25	96	0
	Panama	8	56	82	18
	Bay Bonaventuro	3	58	80	06
	Islands of Gallopega	0	0	90	10
	Cape del Ajugo	6	38 S	83	50
	Lima	2	30 S	77	10

Arica

	Places Names.	Latitude N. or S. D.	M.		Longitude E. or W. D.	M.	
C. of *Amer.* in the S. Sea from *California* to C. *Horn.*	*Arica*	18	12	South Latitude.	73	10	West Longitude.
	La Sarena	24	40		76	32	
	Iſland Juan Fernando	33	20		86	48	
	Baldivia	39	35		81	20	
	Port Stevens	49	50		82	36	
	Cape Victory	52	15		83	20	
	Cape Horn	57	34		74	55	
C. of *Brazil* in S. *America* from *Cape Horn* to *Cape Roque.*	*Magellan E. Entrance*	52	28		75	30	
	River Julian	48	40		69	32	
	Cape Blanco near River Camarones	46	50		67	50	
	Buenos Aries R. Plata	35	30		58	0	
	River Grand	31	55		51	40	
	St. Katherines	28	0		47	50	
	Cape Frio	22	45		42	56	
	Spirito Sancto	20	30		41	0	
	P. Segura	16	52		40	0	
	Bay Todus Sanctus	13	0		40	0	
	River St. Franciſco	10	35		37	46	
	Cape St. Auguſtine	8	25		34	38	
	Cape Roque	5	0		34	42	
	Triſtian de Cunha	37	5		16	0	
	Trinidada	20	30		30	0	
The Coaſt of the Main Contin. in the *Weſt-Indies.*	*R. Amazones Entrance*	0	0	North Latitude.	49	0	
	North Cape	2	5		48	55	
	Surnam	6	0		55	35	
	Oronoque	8	15		59	5	
	C. Coquibaca	12	58		68	40	
	Carthagena	10	40		73	50	
	Scots Settlement	8	30		76	45	

Ni-

	Places Names.	Latitude N. or S.		Longitude E. or W.	
		D.	M.	D.	M.
C. of the M. Cont. in the *West-Indies.*	*Nicaraque Entrance*	11	15 N. Latitude	84	5 W. Longitude
	Cape Catoche	21	22	88	15
	Campeche	19	20	92	5
	La Vera Cruz	19	15	98	55
	Cape Florida	24	48	81	55
The *Caribbee Islands.*	*Trinidada*	10	4 North Latitude.	60	5 West Longitude.
	Tobago	11	0	59	0
	Granada	12	7	60	30
	Barbadoes	13	10	58	3
	St. Vincent	13	6	59	22
	St. Lucia	13	56	59	27
	Martinico	14	48	59	25
	Dominico	15	5	59	27
	Marigalante	15	33	59	20
	Guardalupa	16	0	59	23
	Monserat	16	40	60	35
	Antegoa	17	0	60	0
	Nevis	17	6	61	38
	St. Christophers	17	22	61	35
	Barbuda	17	43	60	5
	St. Bartholomew	17	34	62	5
	St. Martins	18	5	60	49
	Anguilla	17	53	62	5
	Virgins	18	23	53	55
	St. Cruz	17	38	62	35
	Bieque	18	0	63	15
	Port Rico St. John's	18	33	65	20
	St. Domingo Hispan.	18	15	69	50
	Port Royal Jamaica	18	0	77	3
	East End *of Cuba*	20	20	74	25
	Havana	22	50	82	40
	Bay Honda	22	35	84	40
	Cape St. Antonia	21	50	85	42

	Places Names.	Latitude N. or S. D.	M.	Longitude E. or W. D.	M.
Bahama Islands.	*Bermudas*	32	30	61	30
	Bahama Bank N. point	28	22	78	15
	Bahama Islands	27	5	78	58
	Abacca S. point	25	50	77	20
	Harbour Island	25	40	76	35
	Andros N. point	25	15	79	0
	Providence	25	0	77	45
	Illathera S. point	24	30	76	12
	Cat Island	24	25	75	20
	Watling Island	24	7	74	50
	Rum Key	23	45	75	5
	Exuma	23	25	76	7
	Crooked Isle N. point	23	3	74	0
	Atkins Key	22	0	74	15
	Morapervouz	21	57	74	40
	Atwoods Key	22	9	73	30
Bahama Islands.	*French Keys*	22	40	73	35
	Mayaguana	22	35	73	0
	Hogsties	21	15	73	50
	Hyneago	20	57	73	20
	Cancos Bank N point	21	50	71	15
	Turks Island	21	35	70	8
	Abrolho N. point	21	40	68	40
	Plate wrack	20	30	68	10
C. of Carolina, Virginia, Maryland, Pensilvania, &c.	*Charles Town upon Ashly R.*	32	40	78	50
	Cape Hatteras	35	10	74	25
	Cape Henry	37	0	74	30
	Cape Charles	37	14	74	15
	Cape Hinlopen	39	4	73	25
	Long Island	40	50	70	40
	New York	41	0	72	5

North Latitude. West Longitude.

Cape

	Places Names.	Latitude N. or S. D.	M.	Longitude E. or W. D.	M.
The Coaſt of *Carolina, Virginia, Maryland, Penſilvania, New-England, and New-foundland.*	*Cape Cod*	42	10	67	45
	Boſton	42	35	68	50
	Cape Sable	43	45	63	25
	Iſland Sable	44	30	59	5
	Cape Britain	46	20	58	15
	Quebeck	47	15	68	10
	Bay of Breſt	52	10	55	0
	Bell Iſland	52	5	54	10
	Cape St. John	50	9	52	35
	Cape Bonaviſta	49	11	52	3
	Trinity Bay	48	27	52	15
	Conception Bay	47	53	52	0
	St. John's Harbour	47	28	51	25
	Bay of Bulls	47	40	51	6
	Cape Race	46	30	51	25
	Cape St Mary	47	10	53	20
	Placentia	47	57	53	0
	Cape Roy	48	21	57	15
The Coaſt of *Hudſon's Bay* and *Straits.*	*Buttons Iſle*	60	5	66	50
	C. Charles	62	35	75	20
	C. Walſingham	63	15	77	40
	Mansfield Iſle	62	20	80	50
	C. Jones	55	3	79	15
	Ruperts River	51	16	79	55
	Albany River	52	32	84	7
	The Cubbs	54	15	82	0
	C. Henrietta Maria	55	5	84	2
	Port Nelſon	57	5	92	47
	C. Churchill	59	0	92	57
	C. Southampton	61	57	88	30
	Shark Point	64	27	83	20
	Nottingham Iſle	63	38	79	47
	Queen Ann's Foreland	63	32	73	57
	Reſolution Iſle	61	55	65	50
	Cape Farewell	59	10	46	35

North Latitude. West Longitude.

Sound

The Coaſt of *Ireland*, *Greenland*, *Nova Zembla*, and the Northern Iſles.

Places Names.	Latitude N. or S.		Longitude E. or W.	
	D.	M.	D.	M.
Sound Royal	66	22	14	15
Bargarzar Point	66	30	1	12
Whales Back	65	27	10	5
Merchants Foreland	63	20	14	5
Halliford	64	30	24	15
Fair Foreland	65	10	26	45
Grims Iſland	66	51	17	45
Weſtmania Iſles	63	55	18	10
Fero Iſles	62	6	5	0
Beerenberg, or John Mayns Iſles	71	45	4	30
Point Lookout	76	40	16	25
Horn Sound	77	23	14	20
Fair Foreland	79	18	10	50
Hacluits Headland	79	55	12	0
Helies Sound	79	15	12	5
Lees Foreland	78	5	23	25
Whales Head	77	11	21	30
Hope Iſland	70	22	21	8
Cherry or Bear Iſle	74	35	18	50
Admiralty Iſland	75	5	59	50
Fretum Borrough	69	55	62	5
Cape Candenoſe	69	27	42	30
Catſnoſe	65	43	35	14
Archangle-bar	65	5	35	30
Croſs-Iſland	66	31	36	33
Sweetſnoſe	68	8	36	42
Kilduyn	69	33	31	15
North Cape	71	25	22	0
Surroy	71	5	18	40
Tromſound	70	18	16	0
Leefort SW. Point	67	47	9	35
Dronton	64	0	10	40
Stadland	62	10	4	38
North-bergen	60	16	5	40
Naze of Norway	57	50	7	22

North Latitude. West Longitude.

Mar-

	Places Names.	Latitude N. or S. D.	M.	Longitude E. or W. D.	M.
The Sea-Coaſt in the *Sound* and *Baltick* Sea.	*Maruow*	58	25	9	5
	Larwick	58	54	9	20
	Chriſtiana	59	10	9	45
	Maeſterland	57	58	11	45
	Gottenberg	57	33	12	25
	Elſinor	56	0	12	32
	Copenhagen	55	44	12	35
	Valſterborn	55	20	12	55
	Kalmer	56	40	16	40
	Stockholm	59	20	18	25
	Wyborg	60	20	29	26
	Peterſberg	59	25	29	50
	Narve	58	39	28	14
	Revel	59	0	24	45
	Riga	56	50	24	50
	Derwinda	57	20	22	0
	Conningſberg	55	0	20	20
	Dantzick	54	22	19	0
	Wiſbuy in Gotland	57	37	18	50
	Bornholm	55	27	14	53
	Straelſound	54	45	13	20
	Lubeck	54	25	11	5
	Anout	56	42	10	58
	Leſow	57	6	10	40
	Scaw	57	26	10	10

North Latitude. East Longitude.

A TABLE of the *Sun's Right Aſcenſion.*

Month Days	*Jan.*		*Feb.*		*March*		*April*		*May*		*June*	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	18	47	20	58	22	48	0	44	2	36	4	38
2	18	51	21	3	22	52	0	48	2	40	4	42
3	18	55	21	7	22	55	0	51	2	44	4	46
4	19	0	21	11	22	59	0	55	2	48	4	50
5	19	4	21	15	23	3	0	59	2	51	4	54
6	19	8	21	19	23	6	1	3	2	55	4	58
7	19	13	21	23	23	10	1	6	2	59	5	2
8	19	17	21	27	23	13	1	10	3	3	5	6
9	19	22	21	31	23	17	1	14	3	7	5	11
10	19	26	21	35	23	21	1	17	3	10	5	15
11	19	30	21	38	23	25	1	21	3	14	5	19
12	19	35	21	42	23	28	1	25	3	18	5	23
13	19	39	21	46	23	31	1	29	3	22	5	27
14	19	43	21	50	23	35	1	33	3	26	5	31
15	19	47	21	54	23	39	1	36	3	30	5	36
16	19	51	21	58	23	43	1	40	3	34	5	40
17	19	56	22	2	23	46	1	44	3	38	5	44
18	20	0	22	6	23	50	1	47	3	42	5	48
19	20	4	22	10	23	54	1	51	3	46	5	52
20	20	9	22	14	23	58	1	54	3	50	5	56
21	20	13	22	17	0	2	1	58	3	54	6	0
22	20	17	22	21	0	6	2	2	3	58	6	4
23	20	22	22	25	0	10	2	6	4	2	6	8
24	20	26	22	29	0	13	2	10	4	6	6	12
25	20	30	22	33	0	17	2	13	4	10	6	17
26	20	34	22	36	0	21	2	17	4	14	6	21
27	20	38	22	40	0	25	2	21	4	18	6	25
28	20	42	22	44	0	29	2	25	4	22	6	29
29	20	46			0	32	2	29	4	26	6	33
30	20	50			0	36	2	32	4	30	6	38
31	20	54			0	40				34		

A TABLE of the *Sun's Right Aſcenſion.*

Month Days	*July*		*Auguſt*		*Sept.*		*October*		*Novem.*		*Decem.*	
	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.	H.	M.
1	6	42	8	47	10	43	12	31	14	28	16	32
2	6	46	8	51	10	46	12	35	14	32	16	36
3	6	50	8	57	10	50	12	38	14	36	16	40
4	6	54	8	59	10	53	12	42	14	39	16	44
5	6	58	9	2	10	57	12	45	14	43	16	48
6	7	2	9	6	11	1	12	49	14	47	16	53
7	7	6	9	10	11	4	12	53	14	51	16	57
8	7	10	9	14	11	8	12	57	14	55	17	1
9	7	14	9	17	11	11	13	1	14	59	17	5
10	7	19	9	21	11	15	13	4	15	3	17	10
11	7	23	9	25	11	19	13	8	15	7	17	14
12	7	27	9	29	11	23	13	12	15	11	17	19
13	7	31	9	33	11	26	13	15	15	15	17	24
14	7	35	9	37	11	30	13	19	15	19	17	28
15	7	39	9	40	11	33	13	22	15	23	17	33
16	7	43	9	44	11	37	13	26	15	27	17	37
17	7	47	9	48	11	41	13	30	15	31	17	41
18	7	51	9	51	11	44	13	34	15	35	17	46
19	7	55	9	53	11	48	13	38	15	39	17	50
20	7	59	9	58	11	51	13	41	15	44	17	54
21	8	3	10	2	11	55	13	45	15	48	17	58
22	8	7	10	6	11	59	13	49	15	53	18	3
23	8	11	10	10	12	2	13	53	15	57	18	7
24	8	15	10	14	12	6	13	57	16	2	18	12
25	8	19	10	17	12	9	14	0	16	6	18	17
26	8	23	10	21	12	13	14	4	16	11	18	22
27	8	27	10	25	12	17	14	8	16	15	18	26
28	8	31	10	28	12	20	14	12	16	19	18	31
29	8	35	10	32	12	24	14	16	16	23	18	35
30	8	39	10	35	12	27	14	20	16	28	18	39
31	8	43	10	39			14	24			18	43

A TABLE *of the Declination, Right-Aſcenſion and Magnitude of the Principal Fixed Stars.*

Names of the Stars.	Magnitude	Right Aſcen. H.	M.	Declination. D.	M.
Pole Star	2	0	22	87	33 N
Girdle of Andromeda	2	0	50	33	10 N
Acarner	1	1	25	58	55 S
Bright * of ♈	1	1	51	22	04 N
Meduſaes Head	3	2	44	02	42 N
Perſeus Right Side	2	2	59	48	33 N
Brighteſt of 7 *'s	2	3	29	22	55 N
Bull's Eye Aldebaran	1	4	16	15	46 N
Goat Capella	1	4	52	45	37 N
Orions Left Foot	1	4	59	08	38 S
Orions Left Shoulder	3	5	06	05	59 N
Middle Star in Orion's Belt	3	5	19	01	27 S
Orions Right Shoulder	2	5	36	07	18 N
Waggoner	2	5	39	44	56 N
Syrius the Great Dog	1	6	32	16	20 S
Caſtor	2	7	12	32	30 N
Procyon the Little Dog	2	7	24	05	57 N
Pollux	2	7	24	28	28 N
South Arm of Crab	3	8	40	13	48 N
Hydraes Heart	1	9	10	07	10 S
Lyon's Neck	1	9	50	21	41 N
Lyon's Heart	1	9	50	13	39 N
Upper Pointer	2	10	43	63	32 N
Lyon's Tail	1	11	31	18	12 N
Virgin's Girdle	3	12	38	05	20 N
Virgin's Spike	1	13	10	09	31 S
Arcturus	1	14	00	20	53 N
South Ballance	2	14	32	14	35 S
North Ballance	3	15	58	08	03 S
Scorpion's Heart	1	16	08	25	35 S
Head of Orphincus	2	17	22	12	48 N
Brighteſt in the Harp	1	18	25	38	30 N
Vulture's Heart	2	19	34	08	00 N
Swan's Tail	2	20	30	44	05 N
Pegaſus's Mouth	3	21	27	08	12 N
Fomelhaut	1	22	30	31	51 S
Marchab	2	22	50	13	40 N
Pegaſus's lower Wing	2	23	55	33	25 N

The

The Uſe of the Table of Fixed Star's, *and* Sun's Right Aſcenſion.

FIRST, Suppoſe you ſee a Star upon the Meridian, and know not what Star it is, ſee for the Sun's Right Aſcenſion the Day propoſed, and to that add the Hour of the Night when the Star is upon the Meridian, caſting away 24, if it exceeds; and for that Sum look in the Table of Fixed Stars, under [Right Aſcenſion,] and the Star againſt which it ſtands is the Star that you ſaw upon the Meridian.

Example. January 11, and at 11 at Night, I ſee a Star upon the Meridian, which I ſuppoſe to be of the Firſt Magnitude, *viz.* one of the biggeſt of the Fixed Stars; I find the Sun's Right Aſcenſion that Day 19 30, to which add the Hour of the Night 11, the Sum is 30, 30, but caſting away 24, there reſts 6.30, which I look for in the Table of Fixed Stars, under [Right Aſcenſion] and find it to ſtand againſt *Syrius*, the *Great Dog*, ſo I know it is the *Great Dog* that I ſaw upon the Meridian, which is a Star of the firſt Magnitude: and ſo in others.

But if you know a Star, and deſire to know what Time it will be upon the Meridian, ſubtract the Right Aſcenſion of the Sun that Day from the Right Aſcenſion of the Star mentioned in the Table (borrowing 24, if need be) the Remainder is the Time of the Star's coming to the Meridian. *Example*; I deſire to know what Time the *Great Dog* comes to South *February* the 12th, the Sun's Right Aſcenſion that Day is 21, 42, which ſubtracted from 6 30, to the (Right Aſcenſion of the *Great Dog*) by adding

adding 24, becauſe it cannot be done otherwiſe, the Sum is 30, 30, from which take 21, 42, the Remainder 8, 48 is the Hour of the Night that the *Great Dog* comes to the South.

Again, if you ſee a known Star upon the Meridian, and deſire thereby to know the Time of the Night, you may preſently know what Hour it is by the aboveſaid Rule; and in common Caſes, if you know the Time of a known Star's coming to the Meridian, you may nearly compute it, by allowing 4 Minutes to every Day. *Example*, I have found as above, that the *Great-Dog* Souths *February* the 12th, at 48 Minutes paſt 8 at Night; and ſeeing the ſame Star upon the Meridian *February* the 20th, I deſire to know the Hour of the Night; now from *February* 12 to *February* 20, is 8 Days, which allowing 4 Minutes a Day, amounts to 32 Minutes, which ſubtracted from 8 Hours 48 Minutes, the Time of the *Great-Dog's* Southing *February* the 20th. This Allowance of 4 Minutes a Day may ſerve for common Uſe, but if you would be exact, work by the preceding Rules.

In the laſt Column of the Table, you have the Declination of the Fixed Stars, which is of Uſe in taking an Obſervation; Of which ſee more in Chapter VII. Section IV. of this Treatiſe.

The Magnitude is of Uſe to know the Bigneſs of a Star; thoſe of the firſt Magnitude being the biggeſt; the ſixth the leaſt, and the reſt of Bigneſs proportionable to their Magnitudes expreſs'd in the Table.

Chap.

CHAP. IX.

Containing ſeveral Pleaſant and Uſeful Queſtions.

SECT. I. *Of Currents.*

IN ſailing in a Current it is very evident, that a Ship doth not make her Way good according to the Courſe ſteered by the Compaſs, and the Diſtance run by the Log, but being at the ſame Time privately carried by a Current, her true Courſe and Diſtance is compounded of the Courſe, and Diſtance ſail'd, and of the Courſe and Motion of the Current; therefore where both theſe are given, you muſt firſt lay down the Courſe and Motion of the Current; and the Courſe and Diſtance from the Place ſail'd from; to this laſt Place thus found, is the true Courſe and Diſtance made good, as in the firſt Caſe following: A Ship ſails S.E. 100 Miles from C to A, and a Current ſets in the ſame Time Weſt 30 Miles; now if there was no Current, the true Courſe and Diſtance of the Ship would be repreſented by the Line C A, and the Point A ſhould repreſent the Place ſailed to, but becauſe a Current ſets Weſt 30 Miles in the ſame Time, I ſet off 30 Miles W. from A to D, and the Point D, repreſents the Place ſailed to, and the Line C D is

the true Courſe and Diſtance made good; and hence in every Queſtion in Currents, there is conſtituted a Plane Triangle, either Right-angled or Oblique, the Angles of which ſome call the Angles of Reflection, Deflection and Incidence, as Mr. *Norwood* in his *Seaman's Practice*; but by the learned Mr. *T. P.* more properly the Angle of Force, the Angle of Submiſſion, and the Angle of Chance: But I ſhall not trouble the Learner's Memory with theſe Terms, but call them as indeed they are, the Courſe ſteered, or the Courſe made good, *&c.* And therefore, *Note*; That by the Courſe, or the Courſe ſteered, I mean the Courſe by the Compaſs, and by the Diſtance, I mean the Diſtance by the Log; but by Courſe and Diſtance made good, I mean the true Courſe and Diſtance of the Ship from the Place ſail'd from, to the Place come to, with Allowance for the Current, *&c.*

There are ſeveral Caſes and Varieties in Currents, but three are chiefly uſeful: The firſt is, when the Courſe and Diſtance is given, with the Courſe and Motion of the Current alſo given, to find the Courſe and Diſtance made good. The ſecond is, when the Courſe and Diſtance ſail'd, and Courſe and Diſtance made good is given, to find the Courſe and Motion of the Current. The third is, when the Courſe and Diſtance made good, and Courſe and Motion of the Current is given, to find the Courſe and Diſtance ſail'd, and this is of great Uſe when the Bearing and Diſtance of two Ports or Iſlands are given, and the Courſe and Motion of a Current between them is alſo given, to find how much to lay your Ship to the Windward of her true Courſe, that ſo the Set of the Current with that Courſe ſteered may juſt bring her to the propoſed Port.

CASE I. *Courſe and Diſtance ſail'd, and Courſe and Motion of the Current given, to find the Courſe and Diſtance made good.*

Geometrical Conſtructions.

A Ship ſails S. E. 100 Miles in 24 Hours, in a Current that ſets Weſt 30 Miles in the ſame Time, I demand what

what is the true Courſe and Diſtance made good in 24 Hours Time. With the Courſe South Eaſt, and Diſtance 100 lay it down as in Plane Sailing Geometrical, and then it will appear as in the Triangle A B C, *Fig.* 66. and the Ship ſhould be at A; but becauſe the Current ſets 30 Miles Weſt in the ſame Time, ſet off 30 Miles from A to D becauſe from A to D is Weſt; then is the true Place of the Ship at D; therefore draw the Line CD, then is the Triangle CBD the true Projection of the Queſtion, with Allowance for the Current, in which the Angle BCD 29.56 is the true Courſe made good, the Hypotenuſe CD 81.6 the Diſtance, the Leg CB 70.7 is the Difference of Latitude, and BD 40.7 is the Departure, as may be found by meaſuring them Geometrically.

Arithmetical Calculation.

By Caſe the firſt of Plane Sailing.

As Radius — — —	90	0	—	10.00000
To the Diſtance — —	10	0	—	2.00000
So Sine Comp. Courſe —	45	0	—	9.84948
To the Difference of Latitude	70	7	—	1.84948

The Departure is alſo 70.7 equal to the Difference of Latitude, becauſe the Courſe is South Eaſt, *viz.* at an Angle of 45 Degrees.

But becauſe the Current had ſet her 30 Miles Weſt in the ſame Time, therefore ſubtract 30 from the Departure found 70.7 there remains 40.7, the true Departure with Allowance for the Current.

Then you have the true Difference of Latitude and Departure given to find her Courſe and Diſtance, by Caſe the Sixth of Plane Sailing.

As Difference of Latitude — —	70	7	—	1.84948
To Radius — — —	90	0	—	10.00000
So true Departure — — —	40	0	—	1.60959
To Tangent of the Courſe —	29	56	—	9.76011

Then for the Diſtance.

As Sine of the Courſe	29 56	—	9.69809
To the Departure	40 7	—	1.60959
So is Radius	90 0	—	10.00000
To the Diſtance made good	81 6	—	1.91150

Or the Diſtance may be found thus, by Caſe the fourth of Oblique Plane Triangles.

In the Oblique Triangles BCD there is given the Side BC 100, and the Side DC 30, and the Angle between them 45 Degrees: Then by Caſe the fourth of Oblique Plane Triangles.

		Co. Ar.
As the Sum of the Sides	130	7.88606
To the Difference of the Sides	70	7.84509
So the Tang. of half the Sum of the unknown Angles.	67.30	10.38277
To the Tang. of half their Diff.	52.26	10.11392

Hence the Angle BDC is 119.56, and the Angle DBC is 15.4.

Then for the Side BD, which is the true Diſtance made good.

As Side of DBC	15d. 4m.	Co. Ar.	058513
To the Side D C	50	—	1.47712
So is the Sine of BCD	45 0	—	9.84948
To the Side BD 81.6 the Diſtance required		—	11.61173

But ſuppoſe the Current had ſet upon an Oblique Courſe, and not due Eaſt, Weſt, North, or South, the Operation had been more difficult: As for Example.

A Ship

A Ship ſails S. E. 100 *Miles a Day, in a Current that ſets* N.N.W. 30 *Miles a Day; I demand the Courſe, Diſtance, Difference of Latitude, and Departure made good in one Day.*

Geometrical Conſtructions.

Lay down the Triangle ABC, as in the foregoing Queſtion, with the Courſe S. E. *viz.* an Angle of 45 Degrees, the Diſtance 100, the Difference of Latitude 70.7, and the Departure the ſame as found before; then ſhould the Ship be at A; but becauſe the Current in that Time hath ſet the Ship 30 Miles NNW. therefore ſet off 30 Miles N.N.W. from A to *d*, which may be done by the Rule laid down in Traverſe Sailing Geometrical; for ſeeing the Line CA is South Eaſt from C to A, it muſt needs be North Weſt from A to C; and then ſeeing the Current ſets N.N.W. which is 2 Points to the Northward of North Weſt; therefore with the Chord of 60, and one Foot in A, draw the Arch *g d* upon which ſet off 2 Points from *g* to *d*, and draw A *d*, which is a N.N.W. Line, upon which ſet off 30 (the Current's Race) from A to *d*, and then is the true Place of the Ship at *d*, her true Diſtance, C *d* 73.2 Miles, her Difference of Latitude *c q* 43.0 Miles, and her Departure *q d* 59.2 Miles, and the Arch *k h* meaſures the Angle at C 54d. 0m. the Courſe required. *Fig.* 67.

Arithmetical Calculation.

In the Triangle A S *d* Right-angle at S, you have given the Hypotenuſe A *d* 30, and the Angle at A 67.30 (becauſe A *d* is a N.N.W. Line) to find A S and S *d* by the firſt of Right-angled Plane Triangles.

As Radius	90 00	10.00000
To the Hypotenuſe A *d*	30	1.47712
So is the Sine of the Angle at A	67 30	9.96561
To the Leg S *d*	27 7	*x*1.44273

As Radius	90 00	10.00000
To the Hypotenuſe A *d*	30	1.47712
So is the Sine of the Angle at *d*	22 30	9.58284
To the Leg A S	11 5	*x*1.05996

The Leg S *d* 27.7 equal to *q* B, ſubtracted from the whole Difference of Latitude CB 70.7, leaves C *q* the true Difference of Latitude 43.0; and the Leg SA 11.5, ſubtracted from the whole Departure 70.7, leaves 59.2, the true Departure: By which you may find the true Courſe and Diſtance by Caſe the ſixth of Plane Sailing.

As Difference of Latitude	43 0	1.63346
To Radius	90 0	10.00000
So is the Departure	59 2	1.77232
To the Tangent of the Courſe	54 0	10.13886

As Sine Comp. Courſe S. C	54 0	9.76921
To Difference of Latitude	43 0	1.63346
So is Radius	90 0	10.00000
To the Diſtance	73 2	1.86425

The true Courſe is 54 Degrees from the South Eaſtward, or South Eaſt near three quarters Eaſt, and the Diſtance is 73.2 Miles.

CASE

CASE II. *Courſe and Diſtance ſailed, and Courſe and Diſtance made good, given, to find the Courſe and Motion of the Current.*

A Ship ſails (by the Compaſs) S. by E. 36 Miles, and then arrives at a Place which is known to bear from the Place ſail'd from S.E. by S. 54 Miles, (having been deceived by an unknown Current) I demand which Way the Current ſets, and how faſt, ſuppoſing the Ship to ſail by the Log 4 Miles an Hour.

Geometrical Conſtructions.

In this and all other Caſes of Currents, as well as Plane Sailing, Traverſe, *&c.* draw the North and South Line A B, and ſet off the Courſe ſteer'd S. by E. and Diſtance 36 Miles from A to C; then ſet off alſo the Courſe and Diſtance made good 54 Miles S.E. by S. from A to D: Then becauſe by the Courſe ſteer'd by the Compaſs, and Diſtance run by the Log, the Ship ſhould have been at C, but is found at D, therefore I am ſure there is ſome Current hath ſet me in the ſame Time from C to D, therefore draw the Line CD for the Set of the Current, which meaſured will be found to be 25 Miles. And the Angle ACD accounted from the N. by W. Point (becauſe the Line CA is a N. by W. Line) will be found to be 11 Points from the N. by W. Eaſtwards, *viz.* E.S.E. od. 9m. Southerly, for the true Courſe of the Current by the Rule laid down in Traverſe Sailing Geometrical for laying down Courſes by Diſtance of Point. *Fig.* 68.

Arithmetical Calculation.

In the Oblique Triangle A C D, you have given the Side A C 36 Miles, and the Side A D 54 Miles, and the Angle between them 2 Points, or 22d. 30m. (being the Diſtance between S. by E. and S. E. by S.) to find the

Angle ACD, and the Side CD, by Caſe the fourth of Oblique Plane Triangles.

		Co. Ar.
As the Sum of the given Sides	90	8.04576
To their Difference	18	1.25527
So Tang. of ½ Sum of unknown Angles	78.45	10.70134
To Tang. of ½ their Difference	45.9	10.00237

The half Difference of the Angles — 45d. 9m.
Added to the half Sum — 78 45

The Sum is the Angle ACD — 123 54

which reduced to Points of the Compaſs, is 11 Points, 0 Deg. 9 Min. and that accounted from N. by W. finds E.S.E. 0 deg. 9 min. Southerly, for the true Courſe of the Current.

Then for the Side CD the Current's Race in that Time.

			Co. Ar.
As Sine of the Angle ACD	123d.	54m.	0.08092
To the Side AD	54		1.73239
So is Sine of the Angle CAD	22	30	9.58283
To the Side CD required	25		1.39614

So that the Current ſets 25 Miles E.S.E. 9m. Southerly, in the Time that the Ship ſail'd by the Log, 36 Miles S. by E. and ſuppoſing the Ship to ſail 4 Miles an Hour, ſhe would ſail 36 Miles in 9 Hours, in which Time the Current ſets 25 Miles, therefore divide 25 by 9, the Quotient $2\frac{7}{9}$ Miles is the hourly Motion of the Current.

CASE III. Courſe and Diſtance made good by the Ship, and Courſe and Motion of the Current given, to find the Courſe and Diſtance ſail'd: Or, more properly thus, having the Bearing and Diſtance, between two Ports or Iſlands given, and having alſo the Courſe and Motion of a Current that lies between them given, to find what Courſe to ſteer by the Compaſs, or how much to

to Windward of your true Courſe to ſteer, that ſo the Compound Motion of the Ship may juſt ſet her to the deſired Port.

There are two Iſlands A and B; the Courſe from B to A is South 40 Degrees, Weſterly, 80 Miles: The Current ſets Eaſt 2½ Miles an Hour, a Ship ſails 4½ Miles an Hour, I demand what Courſe ſhe muſt ſteer from B to A, and how far ſhe muſt ſail by the Log before ſhe arrives at A, the Port deſired?

Geometrical Conſtructions.

Draw the N. and S. Line BD, and ſet off the Courſe and Diſtance from B to A South 40 Degrees Weſt, 80 Miles from B to A: Then becauſe the Current ſets Eaſt, draw the Eaſt and Weſt Line AC at Pleaſure, by the Rule laid down in Traverſe Sailing *Geometrical*, then is the Side AB 80 Miles, and the Angle BAC 130d. 0m. given, but you have no other Side nor Angle given in the Oblique Triangle ABC, but you have the Proportion of the two Sides CA and CB, for C repreſents the Motion of the Current 2½ Miles an Hour, and BC repreſents the Motion of the Ship thro' the Water 4½ Miles an Hour: Therefore find the Angle ABC by Caſe the Second of Oblique Plane Triangles. *Fig.* 69.

As the Side BC 4½, or in Decimals	— 4.5	*Co. Ar.*	9.34679
To the Angle BAC	130.0		9.88425
So the Side AB 2½, or	2.5		0.39794
To the Sine of the Angle ABC	— 25.11		9.62898

The Angle ABC is 25d.—11m. therefore make the Angle ABC, 25.11, and draw the Line BC to cut AC in C, and then is the Projection finiſhed, and the Angle ABC 25.11 added to the Angle ABD 40d.—0m. the Sum 65d. 11m. from the South Weſterly, or W. S. W. almoſt ¼ Southerly, is the Courſe that the Ship muſt ſteer to gain the Port with Allowance for the Current.

Then

Then for the Side BC, the Diſtance ſail'd by the Log, ſubtract the Sum of the two Angles A and B 155d.—11m. from 180d.—0m. the Remainder 24d.—49m. is the Angle ACD. Then,

As Sine of the Angle ACB	24.49	*Co. Ar.*	0.37705
To its oppoſite Side BA	80		1.90309
So Sine of the Angle BAC	130—0		9.88425
To the Side oppoſite BC	146		2.16439

The Diſtance ſail'd by the Log, is 146 Miles, and the Rate of Sailing is $4\frac{1}{2}$ Miles an Hour, therefore divide 146 by $4\frac{1}{2}$, the Quotient $32\frac{4}{9}$ is the Hours that the Ship will be in ſailing from B to A.

Now if you would prove the Work, multiply $32\frac{4}{9}$, the Hours that the Ship is in ſailing by $2\frac{1}{2}$, the Miles that the Current ſets in one Hour, the Quotient $18\frac{1}{9}$, is the Miles that the Current ſets in that Time, repreſenting by the Side AC, which you will alſo find to be true by the following Canon.

As Sine of BAC	130.0	*Co. Ar.*	0.11575
To Side oppoſite BC	146		2.16439
So Sine of ABC	25.11		9.62891
To Side oppoſite AC	81.1		1.90905

Note; It is neceſſary in this Caſe to know how faſt the Ship ſails, for the faſter ſhe ſails, the leſs ſhe need lie to Windward of her true Courſe againſt the Current.

Caſe IV. *or* Queſtion IV.

There are other Varieties in ſailing in a Current, ſome of which I ſhall inſtance for the Learner's Improvement and Diverſion.

A Current ſets 32 Miles a Day E.N.E. *a Ship ſailing therein ſteers* S.S.E. *by the Compaſs, and finds that in 24 Hours ſhe is 70 Miles diſtant from the Place ſailed from: I demand upon what Point ſhe hath made her Way good, and how far ſhe hath ſailed by the Log?*

Geometrical Conſtruction.

Draw the N. and S. Line A B, and ſet off the Ship's Courſe ſteer'd S.S.E. 22.30, and draw the Line AC continued; then any where upon that Line, as at C, draw an E.N.E. Line (as the Line DC) by the Rule laid down in Traverſe Sailing Geometrical to repreſent the Set of the Current, upon which ſet off 32 Miles, the Current's Motion in 25 Hours, from C to D, then at the neareſt Diſtance from D to the Line AC, (which here happens to be the Length of the Line CD, becauſe CD is Perpendicular to AC) draw the Parallel *b* D, then with 70 Miles (the Diſtance made good in your Compaſſes, and one Foot in A deſcribe the Arch B *g* continued, and where it cuts the Parallel *b* D as in *g*, begin the Line *g* E, drawing it parallel to the Line DC: Then is A *g* 70 Miles and Diſtance made good, E *g* 32 Miles, the Set of the Current E.N.E. The Line AE 62.3 Miles, the Diſtance ſail'd by the Log, and the Angle E A *g* 27d. 12m. added to the Angle B A C 22d. 30m. the Sum 49d. 42m. is the Courſe made good from the South Eaſtward, or the Arch *k m* meaſured on the Rumbs, gives S.E. 4 Degrees, 42 Minutes Eaſterly. *Fig.* 70.

Arithmetical Calculation.

In the Triangle A E *g* you have given the Diſtance made good A *g* 70 Miles, and the Motion of the Current E *g* 32 Miles, and the Angle A E *g* (which happens here to be a Right-angle) 90 deg. to find the Angle E A *g*, thus:

As

As Side A *g*	——	70	—— 1.84509
To Angle oppoſite A E *g*	——	90 0	—— 10.00000
So Side E *g*	——	32	—— 1.50515
To Angle oppoſite E A *g*	——	27 12	— 9.66006

The Angle E A *g* 27d. 12m. added to the Angle BAC 22.30, the Sum 49.42 is the true Courſe made good from the South Eaſtwards, *viz.* S.E. 4d. 42m. Eaſterly.

Then for the Side A E the Diſtance ſailed by the Log.

As Sine A E *g*	——	90d. 0m.	—— 10.00000
To Side oppoſite A *g*	—	70	—— 1.84509
So Sine A *g* E	——	62 48	—— 9.94910
So Side oppoſite AE	——	62.3	—— 1.79419

The Courſe made good is S.E. 4d. 42m. Eaſterly, and the Diſtance ſail'd by the Log is 62.3 Miles.

And if you would prove the Work by inverting the Queſtion, and propoſing it in the firſt Caſe of Current Sailing, thus,

A Ship ſails S. S. E. 62.3 Miles in a Current that ſets E.N.E. 32 Miles; in the ſame Time, you will find the Anſwer produces 70 Miles S.E. 4d. 42m. Eaſterly, for the Courſe and Diſtance made good.

Note; Although in this Caſe the Triangle A E *g* is Right-angled, becauſe the Current's Race E.N.E. makes a Right-angle with the Ship's Courſe S.S.E. yet in any other Caſe it would have been an Oblique Triangle; but the Rules both for Projection and Calculation would have been the ſame.

Queſtion the Fifth.

A Ship ſails 72 Miles a Day by the Log, in a Current that ſets Eaſt 12 Miles a Day, and then finds that ſhe hath made her Way good South Eaſt, I demand what Courſe ſhe hath ſteer'd by the Compaſs, and what Diſtance ſhe made good?

Geometrical

Geometrical Conſtruction.

Draw AB, and with an Angle of 45 deg. the Courſe made good, draw the Line A C continued, then with 72 the Diſtance ſail'd by the Log, ſweep the Arch B *d*; then any where upon the Line AB, as at B, make an Eaſt and Weſt Line, becauſe the Current ſets Eaſt; then take 12 Miles in your Compaſſes, the Currents Motion, and ſet it parallel to BC, and ſo as that it may juſt extend from the Arch B *d* to the Line AC, as here from *e* to *g*, and draw the Line *e g*, and 'tis done—or if you think this Method too mechanical for laying down the Line *g e*, you may do it thus: You fore-ſee that in the Triangle A *e g* when laid down, there will be given the Side A *e* 72, and the Angle oppoſite to it 45 deg. and the Side *e g* 12, to find the Angle *e* A *g*, thus, *Fig.* 71.

As Side A *e*	——	72 *Co. Ar.*	8.14267
To Sine of the Angle oppoſite A *g e*		45.0 —	9.84948
So Sine *e g*	——	12 —	1.07918
To Sine of Angle oppoſite *g* A *e*	——	6.46 —	9.07133

which added to the Angle A *g e* 45 deg. the Sum 51.46 ſubtracted from 180, leaves 128.14, the Angle A *e g*, therefore having ſet off 72 from A, upon the Line A *e* from A to *e*, at *e* draw the Line *e g*, to make an Angle of 128.14 with the Line A *e*, this Line if carefulſy drawn will juſt contain 12 ſuch Parts, whereof the Line A *e* contains 72, by that Time it is extended to cut the Line A *g*.

Then for the Side A *g* the Diſtance made good.

As Sine *e* A *g*	——	6.46 *Co. Ar.*	0.92867
To Side *e g*	——	12 ——	1.07918
So Sine of A *e g*	——	128.14 —	9.89514
To Side A *g* the Diſtance made good 80	——		1.90299

There-

Therefore for the Courſe ſteer'd, ſubtract the Angle *e* A *g* 6.46 from the whole Angle given *b* A *g* 45, the Remainder 38.14 is the Angle, *b* A *e* the Courſe ſteer'd, and the Side A *g* found to be 80, is the Diſtance made good.

Note; In finding the Sine of any Angle above 90 Degrees, you muſt ſubtract the Angle (whoſe Sine is required) from 180 Degrees, the Sine of the Remainder is the Sine of the Angle required, as in the Example above, where the Sine of 128.14 is required, ſubtract 128.14 from 180, the Remainder 51d. 46m. ſought in the Table of Sines, the Sine anſwering to it is 9.89514, which is alſo the Sine of 128.14 which was required; the Reaſon of which is evident from the Diagram at the Beginning of this Book, in which if you account 128d. 14m. from *k* upon the Arch *k* 90 S, it will reach to the Point *x*, and the Perpendicular *x z* is equal to a Perpendicular let fall from 51d. 46m. as you may obſerve by the Degrees number'd from S upwards towards 90, the ſame Degree and Minute which anſwers to 128.14, if number'd from *k*, anſwers to 51.46, if number'd from S, *&c.*

And thus much for Plane Sailing in a Current; many more Queſtions might be inverted from other *Data*'s, but I would ſtudy Brevity, that the Book may not be too chargeable to the Buyer, ſuppoſing that by a right Underſtanding of theſe Rules, the Ingenious will be able to project and anſwer any other Caſe or Queſtion of this Kind; and as for Traverſe Sailing in a Current, although I thought to have placed it in a Section or Chapter by itſelf, yet I find it altogether needleſs; for the Courſes being firſt reduced to one, by the Rules laid down in Traverſe Sailing, the Operation for allowing for known Currents, or finding the Courſe and Motion of unknown Currents, is the very ſame with the Rules here laid down.

OF

OF TURNING TO WINDWARD IN A CURRENT.

THIS may alſo be divided into ſeveral Caſes, of which I ſhall ſpeak in Order; but that which is chiefly uſeful is where the Courſe and Motion of the Current is given, with the Courſe and Diſtance between the Place ſail'd from, and the Place bound for, and from what Point the Wind blows, and how near the Wind the Ship will make her Way good, (for theſe four Things are commonly given or known) to find how long ſhe muſt lie upon each Tack to gain her Port, ſuppoſing her Rate of running, or Miles ſail'd in an Hour by the Log, be alſo given or known.

Example

Example, Queſtion the Firſt.

There are two Iſlands A B, A is diſtant from B 90 Leagues due North : A Current ſets from A towards B South 2 Miles an Hour, a Ship at A intending for B meets with the Wind at South, gets her Starboard Tacks aboard, and makes her Way good within 72 Degrees of the Wind, and ſails four Miles an Hour by the Log, I demand how long ſhe muſt lie upon each Tack to gain her Port, and what Courſe ſhe makes good ?

Geometrical Conſtruction.

Fig. 72. Draw A B repreſenting the Bearing and Diſtance of the two Iſlands, *viz.* N. 90 Leagues, upon the Middle of which erect the Perpendicular *d* C, then draw the Line AC, to make an Angle of 72 Degrees, with the Line AB, and continue the Line AC till it cut the Perpendicular *d* C in C, and draw the Line CB, ſo ſhall the Iſoſceles Triangle ABC repreſent the two Iſlands, and the Ship's Way to them without any Allowance for the Current, the Line AC repreſenting the Ship's Way with her Starboard Tacks aboard 72 deg. from the Wind, and the Line CB her Way, with her Larboard Tacks aboard to fetch the Iſland; but becauſe every Hour while the Ship ſails four Miles by the Log, the Currents ſets her two Miles to the Southward, therefore find how many Hours the Ship is in ſailing from A to C by the Log; in order to which you muſt find the Side AC by dividing the Iſoſceles Triangle A B C into two Right-angled Triangles A *d* C and B *d* C, then in the Triangle ADC you have given the Leg A *d* 45 (being half the whole Line A B which is 90) and the Angle *d* A C 72 deg. conſequently the Angle AC *d* 18 deg. to find the Hypotenuſe AC, by Caſe the fourth, of Right-angled Plane Triangles.

As

As Sine of A C *d*	—— ——	18d. om. —	9.48998
To Side oppoſite *a d*	—— ——	45 ——	1.65221
So is Radius A *d* C	—— ——	90.0 ——	10.00000
To Hypotenuſe AC	—— ——	145⅓ ——	2.16223

Hence AC is 145⅓ Leagues or 436 Miles, which divided by 4 the Miles ſail'd in one Hour, the Quotient 109 is the Hours, in which the Ship ſails from A to C; but the Current ſetting South two Miles an Hour, 'tis plain that in 109 Hours it hath ſet South 218 Miles, or 72⅔ Leagues; therefore draw the South Line A *g*, becauſe while ſhe ſail'd by the Log from A to C, the Current hath ſet her from C to *g*, therefore draw the Line C *g*, which ſhall repreſent the true compound Motion of the Ship or Courſe made good; but becauſe ſhe is to lie upon that Tack, but only till ſhe be got half Way to the Port ſail'd for, obſerve where the Line A *g* cuts the Perpendicular *d* C as in *e*, and then is the Angle *d* A *e*, 49d. 37m. the true Courſe made good by Reaſon of the Current, and the Line A *e* the true Diſtance ſailed upon the Starboard Tack, *viz.* 69.3 Leagues, and *e* B the Diſtance ſailed upon the Larboard Tack being alſo 69.3 Leagues. But to know how far ſhe will have ſailed by the Log, by that Time that ſhe will be at *e* by the Help of the Current, draw *e k* parallel to *g* C, this Parallel ſhall cut AC and A *g* proportionably by *Euclid Lib.* 6. *Prop.* 2. *viz.* As A *g* to A *e*, ſo A C to A *k*, hence A *k* meaſured will be found to be 55.5 Leagues, or 166.5 Miles ſailed by the Log, which divided by four, the Miles ſailed by the Log in one Hour, given 41¼ Hours, the Time to ſtand upon the Starboard Tack, and the ſame upon the Larboard, to fall in with the Iſland at B, *&c.*

Arithmetical Calculation.

In the Oblique Triangle A C *g*, there is given the Side A C 436 Miles, and the Side C *g* 218 Miles, and the Angle included A C *g* 108d. om. to find the Angle C A *g*,

by Caſe the Fourth of Oblique Angled Plane Triangles.

As Sum of the Sides	654 *Co. Ar.*	7.18443
To Diff. of the Sides	218	2.33845
So Tang. of ½ Sum of unknown Ang.	36.0	9.86126
To Tang. of half their Difference	13.37	9.38414

The half Difference 13d. 37m. ſubtracted from the half Sum 36d. 0m. reſts 22d. 23m. the Angle CA*g*, which ſubtracted from the whole Angle *d*AC 72d. 0m. leaves the Angle *d*A*e* 49d. 37m. the Courſe made good.

Then for the true Diſtance made good A*e*: In the Triangle A*de* you have given A*d* 45 Leagues, and the Angle *d*A*e* 49d. 37m. conſequently the Angle A*ed* 40d. 23m. to find A*e* by Caſe the ſecond of Right-angled Plane Triangles.

As Sine of A*ed*	40d. 23m.	9.81150
To Side oppoſite A*d*	45	1.65221
So Radius	90 0	10.00000
To Hypotenuſe A*e*	69 3	1.84071

Then for the Diſtance ſail'd by the Log A*k* (while by the Help of the Current ſhe is carried to *e*.)

In the Triangle A*ke*, you have given A*e* 69.3, and you have given all the three Angles, *viz.* A*ke*, equal to AC*g* 108d. 0m. and A*ek* equal to A*g*C equal to *d*A*e*, 49d. 37m. and *k*A*e* 22d. 23m. equal to *g*AC, to find the Side A*k* by Caſe the firſt of Oblique-angled Plane Triangles.

As Sine of A*ke*	108d. 0m. *Co. Ar.*	0.02179
To Side oppoſite A*e*	69.3	1.84071
So Sine of A*ek*	49—37	9.88180
To Side oppoſite A*k*	55.5	1.74430

The

The Side A *k*, the Diſtance ſailed by the Log, is 55.5 Leagues, or 166.5 Miles, which divided by 4, the Miles ſailed in one Hour by the Log, the Quotient 412 is the Hours that ſhe muſt lie upon the Starboard Tack, in which Time ſhe is carried away by the Help of the Current from A to *e*, and then lying the ſame Time upon the Larboard-Tack, ſhe will arrive at B, the deſired Port; ſo that in 83 Hours, ſhe performs the Voyage of 90 Leagues, although upon a Wind, by the Help of the Current, which had there been no Current, would have acquired 218 Hours, or 9 Days and 2 Hours.

Queſtion the Second.

There are two Iſlands diſtant 400 *Miles* N. *and* S. *from each other, ſuppoſe* A *and* B, A *being the Northermoſt: A Ship at* A *intending for* B, *meets with the Wind in South, ſhe gets her Starboard Tacks aboard, and makes her Way good through the Water, within* 72 *Degrees of the Wind, a Current at the ſame Time ſetting South* 24 *Miles a Day, ſhe ſtood four Days upon each Tack, and then arrived at her Port at* B: *I demand my Courſe and Diſtance made good upon each Tack?*

Fig. 73.

Geometrical Conſtruction.

Draw the Line AB 400, and at an Angle of 72 Degrees, draw AD and BD, to cut each other in D, and from that Interſection let fall the Perpendicular DC, which will fall upon the Middle of the Line AB, then is the Projection finiſhed without Allowance for the Current; but becauſe in that four Days that ſhe had her Starboard Tacks aboard, the Current had ſet her 96 Miles, ſet off 96 from C to *e* and *h*, and draw *h k* and *e g* Parallel to CD, and where theſe Parallels cut the Lines AD and BD, as at *g* and *k*, draw the Line *g k* to cut the Perpendicular CD in *m*, and then to the

Interſection at *m*, draw the Lines A *m* and B *m*, for theſe Lines ſhall repreſent the true compound Motion of the Ship or Courſe and Diſtance made good, *viz.* The Angle C A *m* 57d. 49m. is the Courſe made good from the Meridian, and the Line A *m* equal to *m* B is the true Diſtance ſail'd upon each Tack, *viz.* 372.6.

Arithmetical Calculation.

In the Triangle A *e g* Right-angled at *e*, you have given the Leg A *e* 104, and the Angle *e* A *g* 72d. conſequently the Angle A *g e* 18d. to find the Hypotenuſe A *g*.

As Sine of A *g e*	18d. om.	—	9.48998
To Side oppoſite A *e*	104	—	2.01703
So Radius	90.0		10.00000
To the Hypotenuſe A *g*	336.5		2.52705

Then in the Oblique Triangle A *g m* you have given the Side A *g* 336.5 and the Side *g m* 96, becauſe equal to C *e*, and the Angle included A *g m* 108d. om. to find the Side A *m*.

		Co. Ar.
As Sum of the Sides	432.5	7.36402
To Difference of the Sides	240.5	2.38111
So Tang. of half Sum of unknown Angles	36.0	9.86126
To Tangent of half their Difference	22.0	9.60639

Hence the Angle *g* A *m* is 14d. oom. which ſubtracted from the whole Angle 72, leaves the Courſe made good, C A *m* 58d. oom. Then for the Diſtance made good.

		Co. Ar.
As Sine of C A *m*	14d. oom.	0.61632
To Side oppoſite *g m*	96	1.98227
So Sine A *g m*	108.0	9.97820
To Side oppoſite A *m*	377.4	2.57679

The

The Diſtance made good upon each Tack is 377.4 Miles; the Diſtance ſailed by the Log upon each Tack is A *g* and B *k* 336.5, the Courſe made good 58d. om. from the Meridian.

Queſtion the Sixth.

A Maſter of a Ship having taken her Freight from and Iſland at A, *to another Iſland at* B, *and having his Son aboard along with him to gain Experience, he requires of his Father, whether there was not a Current ſetting upon ſome Point between the two Iſlands: his Father refuſing to tell him, bids him obſerve well the Dead Reckoning Outward-bound, and alſo Home, and ſee if he could not, by comparing them, find the true Courſe and Motion of the Current: Whereupon the Captain, who knew very well what Way the Current ſet, and how the Iſlands bore upon each other, cauſed them to ſteer away South, and in Running* 270 *Miles upon that Courſe, they arrived at* B, *and having done his Buſineſs there, they ſteered North Weſt, and Running* 380 *Miles upon that Courſe, they arrived at* A. *Now I demand how the Iſlands bear from each other, and how far diſtant; alſo which Way the Current ſets, and how faſt, ſuppoſing the Ship ſailed always at the Rate of* 5 *Miles an Hour by the Log?*

Geometrical Conſtructions.

Draw the North and South Line A C 270 Miles, the firſt Courſe and Diſtance; then becauſe her Courſe home was North Weſt to A, draw the Line AD at the Angle of 45 degrees from A C (becauſe if D A be North Weſt, A D muſt be South Eaſt, and conſequently make an Angle of 45 Degrees with the Line A C) and ſet off 380 from A to D, and draw the Line C D, which repreſents the Motion of the Current during the Ship's ſailing from A to C and from D to A; for the finding of which you have given the Side A C 270, and the Side A D 380, and the contain'd Angle 45 deg. to find the *Fig.* 74.

Angle A C D by Caſe the fourth, of Oblique Plane Triangles.

As Sum of the Sides ———	— 650 *Co. Ar.*	7.18708
To the Difference of the Sides—	110 ———	2.04139
So Tang. of ½ Sum of unkn. Angle	67.30 ——	10.38277
To Tang. of ½ their Difference	— 22.13 ——	9.61124

The half Sum added to the half Difference, makes the bigger Angle ACD 89.43.

Then for the Side C D.

As Sine of A C D ——— ——	89.43 *Co. Ar.*	0.00001
To Side oppoſite A D ———	380 ———	2.57978.
So Sine of CAD ——— ——	45.0 ———	9.84948
To Side oppoſite CD ———	— 268.7 ———	2.42927

The Side CD 268.7 Miles is the Currents Race during the whole Voyage: Now to find the Bearing and Diſtance of the Iſlands, we ſee that in the whole Voyage, out and home, the Ship runs 650 Miles, which at 5 Miles an Hour, requires 130 Hours, in which time the Current ſets 268.7 Miles, but her Voyage outward being but 270 Miles, which at 5 Miles an Hour requires but 54 Hours, therefore ſay by the Rule of Three, if in 130 Hours the Current ſets 268.7 Miles, how far will it ſet in 54 Hours?

268.7	11	9.8	(110$\frac{1}{13}$ fere.
54	1480	0	(
	1333		
10748	11		
13435			
14509.8			

The Current's Drift while the Ship ſails by the Log. from A to C is 110$\frac{1}{13}$ almoſt, but for Eaſe of working we

we will call it 110.8, which ſet upon the Line C D from C to B, and draw A B which repreſents the true Courſe and Diſtance between the two Iſlands, for the finding of which by Calculation, you have given, in the Triangle ABC, the Side AC 270, and the Side CB 110.8, and the contained Angle ACB 89.43, to find the Angle CAB, by Caſe the Fourth, of Oblique Plane Triangles.

		Co.	*Ar.*
As Sum of Sides	380.8		7.41932
To the Difference of the Sides	159.2		2.20194
So Tang. of half Sum unknown Angles	45.8		10.00202
To Tang. of half their Difference	22.47		9.62328

Hence the Angle C A B is 22d. 21m. the true Courſe from A to B South Eaſterly, which is South South Eaſt 9 min. Southerly.

Then for the Side A B the true Diſtance between the Iſlands.

		Co.	*Ar.*
As Sine of C A D	22.21		0.41992
To Side oppoſite C B	110.8		2.04454
So Sine of A C B	89.43		9.99999
To Side oppoſite A B	291.4		2.46445

The true Diſtance between the two Iſlands is 291.4 Miles.

The Courſe of the Current is the Angle A C D, found by the firſt Operation 89d. 43m. from the North Eaſterly, which is Eaſt 17 Minutes Northerly, and as for the Rate or Motion of the Current's running, it is found by dividing the whole of the Currrent 268.7, by the whole Number of Hours that the Ship was under Sail 130, the Quotient is the Miles that the Current ſets in one Hour, as appears by the Operation.

Current ſets in one Hour, as appears by the Operation.

$$130 \overline{)} \begin{matrix} 00 \\ 268.7 \\ 130.3 \end{matrix} \overline{(} \begin{matrix} 87 \\ 2 \text{ ——} \\ 1300 \end{matrix}$$

Hence in Anſwer to what was demanded, the Courſe from A to B is S.S.E. 0d. 9m. Southerly. —— The Diſtance 291.4 Miles the Courſe of the Current is Eaſt 0d. 17m. Northerly, and its Rate or Motion is $2\frac{87}{1300}$ Miles an Hour.

Now if you would prove the Truth of the Operation you may eaſily do it, by inverting the Queſtion, and ſtating it in the firſt Caſe of *Current Sailing*, thus;

A Ship ſails South 5 Miles an Hour in a Current that ſets Eaſt 17 min. Northerly $2\frac{87}{100}$ Miles an Hour, I demand the Courſe and Diſtance made good, and you will find it will produce S.S.E. 9 min. Southerly for the Courſe, and 291.4 Miles for the Diſtance; but I ſhall leave the Operation for the Reader's Practice.

Plea-

Pleaſant and Uſeful

QUESTIONS

I Thought to have added other Varieties of Queſtions concerning Currents; but this being but an Appendix to a ſmall Treatiſe, I fear if I ſhould proceed, I ſhould exceed my intended Bounds, and therefore ſhall add no more, ſuppoſing that by what is laid down the ingenious Student may eaſily Learn to Project and Anſwer any other neceſſary Queſtion in that kind; I ſhall now proceed according to my Promiſe, to inſert ſome other pleaſant and uſeful Queſtions for the Reader's Improvement and Diverſion.

Queſtion the Firſt.

There is a round Sea or Lake of an unknown Diameter, upon which the Wind is obſerved to blow always one Way, but upon what Point of the Compaſs is unknown; upon the Coaſt hereof are two Ports A *and* B, *diametrically oppoſite to each other, ſo ſituate that the Trade Wind blowing there, will be ſomewhere upon the Larboard Quarter, during their ſailing from* A *to* B, *but how many Points abaft the Beam is unknown, the Courſe and Diſtance between the two Ports is alſo unknown.* —— *A Ship at* A *intending for* B, *was no ſooner got out of the Harbour, but he was aſſaulted*

aſſaulted by Pyrates, who after a long Conflict carried away his Main Maſt, Mizen Maſt, Fore Top Maſt, and alſo his Rudder, and came aboard to Plunder, taking away his Goods, his Books, Inſtruments, Charts, Compaſſes, &c. being left in this Diſtreſs he ſets his Fore Sail, and having no Rudder, nor any more Sail to command her with, let her drive Right before the Wind, 'till at laſt ſhe drove a-ſhore in a little Creek, altogether unknown by the Maſter, nor did he know the Courſe or Diſtance from this Creek, either to the Port ſailed from, or to the Port bound for: However here he got ſuch Maſts and Sails as he had Occaſion for, with a Rudder, and all that was neceſſary to the working of a Ship, but could get no Books, Charts, Inſtruments, or Compaſſes: I demand what Means he muſt uſe to guide himſelf to the Port at B?

Anſwer.

Although at firſt Sight this Queſtion ſeems impoſſible to be anſwer'd from what is given, yet with a little Conſideration it is very eaſy; the Solution of it is grounded altogether upon the Thirty-firſt Propoſition of the Third Book of *Euclid*, where it is prov'd that an Angle in a Semicircle is a Right-angle, *&c.* Now the two Ports A and B being propos'd oppoſite to each other, or in a Semicircle, it will neceſſarily follow that to what Place ſoever the Ship was blown from A, right before the Wind, and put a Shore, the ſame Wind upon the Beam would carry her to the Port at B, as appears by the Figure annexed.

Fig. 75. The Angles A C B and A D B and A E B are all Right-angles by the Propoſition above named; and therefore if from A the Ship is blown before the Wind to C, 'tis plain that the ſame Wind continuing, (as is here ſuppoſed) the Wind muſt needs be upon the Beam from C to B, becauſe A C B is juſt Square or Right-angle.

Or, Suppoſe the Wind blow from A to D, and the Ship driven before the Wind is blown a Shore at D, it

is

is plain that (the Angle A B D being a Right-angle) the ſame Wind muſt be upon the Beam from D to B ——— and for the ſame Reaſon, if blown before the Wind from A to E, the Wind will be upon the Beam from E to B; *See the Demonſtraton in the Book itſelf.*

Queſtion the Second.

There is a round Lake, whoſe Diameter is 360 *Miles, upon the Coaſt of which lie two Ports,* A *and* B, *whoſe neareſt Diſtance in a ſtrait Line is* 120 *Miles, but their Bearing & Situation is not known: A Ship at* A *ſails away Weſt a certain Diſtance, and then arrives at another unknown Port at* L, *whoſe Bearing and Diſtance both from* A *and* B *are unknown, and at the Port at* L, *he takes in Goods for* B, I *demand what Courſe he muſt ſteer to find the Port at* B?

Firſt, Draw the Circle K L M N to repreſent the Lake whoſe Diameter K M or L N is 360 Miles, then aſſume any Point in the Circumference of the Circle, as at A; to repreſent the Port at A: then with 120 in your Compaſſes, the Diſtance of the Ports in a ſtrait Line, and one Foot in A, the other will reach to B, biſſect the Arch AB at N, and thro' N and the Center *o*, draw the Diameter N *o* L, and at Right-Angles to it the Diameter K M, and draw the Line A B, then is the Line A *q* B the Chord of the Arch ANB, and B *q* is the Sine of B N to Radius K *o* 180. Therefore, *Fig.* 76.

As K *o* ——— ——— ———	180 ———	2.25527
To Radius ——— ——— ———	90 00 ——	10.00000
So B *q* equal to half B *q* A ———	60 ———	1.77815
To Sine of the Angle B *o q* ——	19.28 ——	9.52288

The Angle B *o q* 19.28 doubled is 38.56, the whole Angle B *o* A (becauſe the Angles B *o q* and *q o* A, are equal.) Now ſuppoſe a Ship at A ſails Weſt to an unknown

known Port at L, I have already proved the Angle A O B to be 38.56, and therefore the Angle A L B is 19.28, becauſe an Angle at the Center of a Circle is double to an Angle at the Circumference, by *Euclid Lib.* 3. *Prop.* 20; and therefore if from A to L be *Weſt*, 'tis plain that from L to B is *Eaſt* 19 Deg. 28 Min. Northerly, and that is his Courſe from L to B.

Or, for Variety if you ſuppoſe the Port at S to be the Port ſailed to, and that from A to S is *Weſt*, then from S to B will be *Weſt* 19 Deg. 28 Min. *North* as before, for the Angles A L B and A S B are equal, as is ſufficiently demonſtrated in *Euclid*'s Elements in the forementioned Propoſition.

Queſtion the Third.

A Fleet of Ships with four Men of War, with Wind at W. by S. *ſails away* S.E. 3 *Miles an Hour, till hearing of ſome Pyrates to the Northward from them, the Commodore ſends out a Man of War a Cruiſing, who ſails due North* 7 *Miles an Hour, for the Space of* 11 *Hours, and finding the Pyrate, he (after an Hours Conflict) took him, the Fleet all the while ſailing* S.E. 3 *Miles an Hour. Now I demand what Courſe the Man of War and the Pyrates muſt ſteer, that they muſt juſt fall in with the Fleet, without altering their Courſe, ſuppoſe they ſail* 7 *Miles an Hour.*

Fig. 77.

Geometrical Conſtruction.

Firſt draw the *North* and *South* Line CA continued to B, then from A (the Place where the Fleet was when they heard of the Pyrates) ſet off the S.E. Line AE; then becauſe the Cruiſing Man of War ſailed 7 Miles an Hour North, for 11 Hours, *viz.* 77 Miles: Set off 77 Miles from A to B, alſo becauſe the Commodore ſailed 3 Miles an Hour in 11 Hours that the Man of War was in Chaſe, and the one Hour that he was engaged, in all 12 Hours, which at 3 Miles an Hour is 36 Miles S.E. which ſet from A to D, then is the Commodore at D, and the Cruizer at B, when the

the Cruiſer ſet ſail after the Commodore: Now becauſe the Line AE is South Eaſt, or 45 Degrees, the Angle BAD is 135 Degrees, the Side A B is 77, and the Side AD 36, to find the other Angles by Caſe the fourth of Obliqe Plane Triangles.

		Co. Ar.
As the Sum of the Sides	113	7.94693
To Difference of the Sides	$4\frac{1}{2}$	1.61278
So Tangent half Sum unknown Angles	20.30	9.61722
To Tangent of half Difference	8.33	9.17693

Hence the Angle ABD is 13.57, and the Angle ADB is 31.3, to find the Side BD by Caſe the Second of Oblique Plane Triangles. *Fig.* 77.

		Co. Ar.
As S. ADB	31.3	0.28754
To Sine A B	77	1.88649
So is S. B A D	135.0	9.84948
To Side BD	105.5	2.02351

Alſo the Angle ADB being 31.3, the Angle BDE muſt be 148.57, and although the Sides BE and DE be not given, yet their Proportion to each other is given, *viz* As 7 to 3, ſo DE to AE, therefore,

		Co. Ar.
As Side B E	7	9.15491
To Sine of Angle oppoſite BDE	148.57	9.71247
So is Side DE	3	0.47712
To Angle oppoſite DBE	12.46	9.34450

The Angle B D E being 148.57, and D B E 12.46, D E B muſt conſequently be 18.17, then you have given the Angles B E D and B D E, and the Side B D

to

to find the Side B E, the Diſtance ſailed by the Cruiſer before he met with the Fleet.

		Co.	*Ar.*
As Sine of B E D	18.17		0.50247
To Side oppoſite B D	105.5		2.02325
So Sine of B D E	148.57		9.71247
To Side oppoſite B E	173.0		2.23819

The whole Angle A B E 26.43 is the Courſe from the South Eaſtward, or S.S.E. 4d. 13m. Eaſterly the Cruiſer muſt ſail to fall in with the Fleet, and his Diſtance 173 Miles before he comes in with them, which at 7 Miles an Hour, would require almoſt 25 Hours, in which Time he will fall in with the Fleet?

Queſtion the Fourth.

Plate 8. Fig. 78.

Two Ships from one Port ſails between the South and Weſt; the Weſtermoſt Ship's Departure was 47 Leagues more than the Eaſtermoſt, and the Eaſtermoſt Ship's Difference of Latitude was 30 Leagues more than the Weſtermoſt. Their Diſtance was equal, namely 115 Leagues, I demand both their Courſes, Difference of Latitude and Departure, according to Plane Sailing.

Geometrical Conſtruction.

Draw the North and South Line GC, and Perpendicular thereto the Line DH, to cut GC at Right-angle in E (both drawn of Length at Pleaſure) from the Interſection at E upon the Line DH ſet the Difference of the Departure 47 from E to D (towards the Left-hand, becauſe the Ships ſail in the South Weſt Quarter) and the Difference of their Latitudes made good, *viz.* 30 from E to C, ſo ſhall D repreſent the Weſtermoſt Ship, and C the place of the Southermoſt. Take the Diſtance 115 Leagues in your Compaſſes, and ſetting

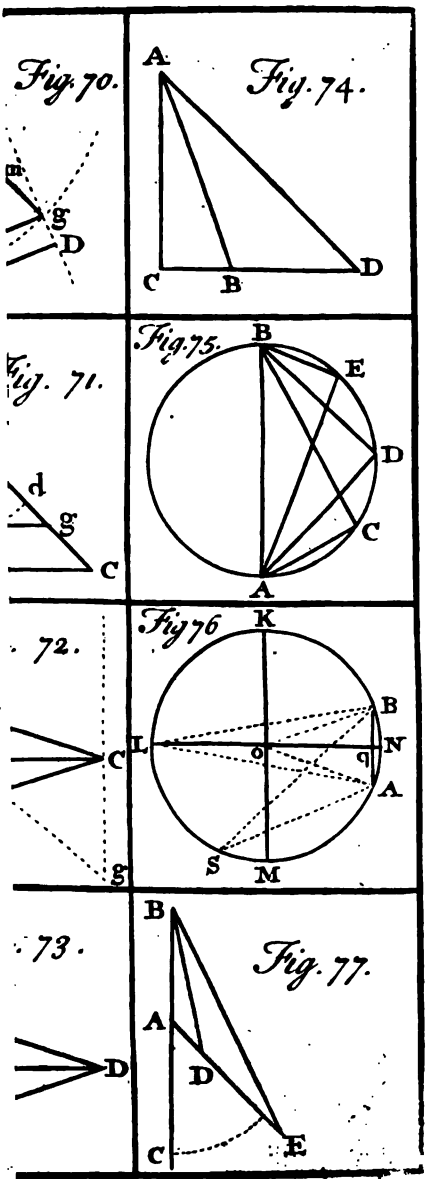


Fig. 70.
m
g
D
Fig. 74.
A
C
B
D
Fig. 71.
d
g
C
Fig. 75.
B
E
D
C
A
72.
C
g
Fig 76
K
B
L
o
q
N
A
S
M
73.
D
B
A
D
C
E
Fig. 77.

page. 350.

to find
fore he

As Sin
To Sid
So Sin

To Sid

The
South
muſt
Miles
an Hou
he will

Two
the W
than th
Latitud
Diſtanc
their Co
to Plan

Dra
theret
drawn
the Li
to D (
South
made
Weſte
Take

ſetting one Foot in D make the Arch A, and with the ſame Extent, and one Foot in C croſs the ſame Arch in A, then is A the Place the Ship ſail'd from. Draw the Line AB parallel to GC to cut DH in H, and from C draw CB parallel to DH. Alſo draw the Perpendicular AL, to divide the Iſcoſceles Triangle ADC into two Right-angled Triangles ALC and ALD, and then is the Diagram finiſhed.

Arithmetical Calculation.

In the Triangle DEC is given,
The Difference of Departure DE ——— 47.
The Difference of the Latitude, E C 30.
To find the Angles by Caſe 6, and the Hypotenuſe by Caſe 7.

And firſt for the Angles by Caſe VI.

As DE	47	1.67209
To Radius		10.00000
So is EC	30	1.47712
To Tang. of the Angle CDE	32.33	9.80503

For the Hypotenuſe DC, by Caſe 7.

As Sine of the Angle EDC	32d. 33m.	9.73081
To Side E C	30	1.47712
So Radius		10.00090
To the Hypotenuſe DC	55.8	1.74631

The Iſcoſceles Triangle D A C being divided into two Right-angled Triangles by the Perpendicular A L, there is given in the Right-angled Triangle ALC, the Side L C (half of D C) 27.9, the Hypotenuſe A C 115, to find the Angle ACL by Caſe 4.

As

As A C	115	2.06069
To Radius		10.00000
So L C	27.9	1.44560
To the Sine of the Angle LAC	14d. 3m	9.38491

The Angle LAC, 14d. 3m. ſubtracted from 90, leaves the Angle LCA 75.57.

The Angle CDE is 32d. 33m. which ſubtracted from 90, leaves the Angle DCE, 57d. 27m.

From the whole Angle DCA (LCA)	75d.	57m.
Subtract the Angle DCE	57	27
Reſts the Angle ECK	18	30

The Angle ECK, is equal to the Angle CAB; becauſe AB and EC are parallel, *Euclid. Lib.* 2. *Prop.* 29. Therefore in the Triangle ABC is given AC 115, and BC the Departure of the Southermoſt Ship, by the firſt Caſe of Plane Sailing.

As Radius		10.00000
To the Diſtance	115	2.06063
So is Sine Comp. Courſe	71d. 30m.	9.97695
To Diff. Lat.	109	2.03764

For the Departure BC.

As Radius		10.00000
To the Diſtance	115	2.06069
So Sine of the Courſe	18d. 30m.	9.50147
To the Departure BC	36¼	1.56216

The firſt Ship's Courſe is South — 18d. 30m. Weſt,
To which add the whole Angle DAC 28 6

The

The Sum is the ſecond Ship's Courſe D A H, which is South 46 36 Weſt.

The firſt Ship's Diff. Lat. is A B ——	109
From which ſubtract the Exceſs H B equal to E C —— —— —	30
Reſts the ſecond Ship's Diff. Lat. A H —	79

The firſt Ship's Departure is C B equal to E H —— —— ——	36½
To which add D E the Exceſs —— —	47
Sum is the ſecond Ship's Depart. D H ——	83½

Firſt Ship's	Courſe South 18d. 30m. Weſt	
	Difference of Latitude ——	109
	Departure —— ——	36½

Second Ship's	Courſe South 46d. 36m. Weſt.	
	Difference of Latitude ——	79
	Departure —— ——	83½

Queſtion the Fifth.

The Diſtance and Difference of Latitude in one Sum given, and the Departure alſo given, to find the Courſe, and alſo the Difference of Latitude and Diſtance ſeverally.

Example.

Let the Diſtance and Difference of Latitude together be 140, and the Departure 79, to form the Triangle, and find as above.

Geometrical Conſtruction.

Draw the Right-line A C 140, equal to the Sum of the Diſtance and Difference of Latitude, and at the End thereof *c* draw *c d*, Perpendicular to A *c*, upon which ſet off the Depar- *Plate* 8. *Fig.* 79.

ture 79 from *c* to *d*, and draw A *d*, which divide in two equal Parts in *g*, and from *g*, erect the Perpendicular *g b* to cut A *c* ſomewhere in *b*, and from *b*, draw *b d*, and then is the Diagram finiſhed, and *b c* is the Difference of Latitude; *b d* the Diſtance, and *c d* the Departure.

Demonſtration.

For the Triangles A *g b* and *d g b* are alike and equal, (*Euclid. Lib.* 1. *Prob.* 24.) becauſe A *g* is equal to *g d* by Conſtruction, and *g b* is common to both Triangles, hence *d b* is equal to A *b*, and the Angle *g* A *b* equal to that of *g d b*, but the Angle *d b c* is equal to both *g* A *b* and *g d b* (*Euclid Lib.* 1. *Prob.* 32.) therefore *d* A *c* (*g* A *b* is juſt half the Angle of the Courſe from the Meridian) and from hence we may form this Univerſal Proportion for the Solution of Queſtions of this Data

As Diſtance and Difference of Latitude in one Sum: To Radius : : Departure : the Tangent of half the Courſe, which Angle doubled is the Courſe required, and the reſt is found by Caſe the Third of Plane Sailing.

Example.

As Diſt. and Diff. Lat. together —	140	—	2.14612
To Radius — — — — —		—	10.00000
So Departure — — — —	79	—	1.89762
To Tangent of — —	29	26	—	9.75150
Which doubled is — —	58	52	the Courſe required.	

Then,

As Sine of the Courſe —	58	52	—	9.93245
To Departure — —	79	—	1.89762
So Radius — — — — — — —				10.00000
To the Diſtance —	92	3	—	1.96517

And,

And,

As Radius — — — — — —		10.00000
To the Diſtance — — — —	92.3 —	1.96517
So Sine Comp. of Courſe — —	31.8 —	9.71351
To Diff. Latitude — — —	47.7 —	1.67868

The Truth hereof may be further proved by adding the

Difference of Latitude — — —	47 : 7
To the Diſtance — — — —	92 : 3
The Sum is — — — —	140 : 0

agreeing with what was firſt given, and proving the whole to be right.

Queſtion the Sixth.

Diſtance and Difference of Latitude in one Sum given, with the Courſe alſo given to conſtruct the Diagram, and find each ſeverally.

We refer in this to the Figure of the laſt Queſtion, it being the ſame when finiſhed. *Plate* 8. *Fig.* 79.

Let it be given as before, *viz.* Diſtance and Difference of Latitude in one Sum 140, and the Courſe South 58d. 52m. Weſt, to find the reſt.

Geometrical Conſtruction.

Draw A *c* 140, and at *c* erect the Perpendicular *c d* at Pleaſure, and at an Angle of 29d. 26m. (*viz.* half the given Angle 58d. 52m.) with A *c* draw A *d* to cut *d c* in *d*, and to make at A the above mentioned Angle of 29d. 26m. divide A *d* in two equal Parts in *g*, and draw *g b* perpendicular to A *d*, and to cut A *c* in *b* draw *b d*, and then is the Scheme finiſhed, and the Demonſtration the ſame as in *Queſtion the Fifth.*

Arithmetical Calculation.

The Angle *c b d* is 58d. 52m. therefore *c d b* is 31d. 8m. to which add *b d g* (equal to *b* A *g*) 29d. 26m. the Sum 60d. 34m. is the whole Angle A *d c*, therefore,

			Co. Ar.
As Sine of *a d c*	60d. 34m.		0.06002
To Side oppoſite	140		2.14612
So Sine of *d a c*	29 26		9.69144
To Departure *c d*	79		1.89758

The Diſtance and Difference of Latitude is found as in *Queſtion the Fifth*, and need not be here repeated.

Queſtion the Seventh.

Given all the three Sides, *viz.* Diſtance, Difference of Latitude and Departure in one Sum, the Courſe alſo given to form the Scheme, and find each ſeverally.

Suppoſe the three Sides in one Sum be 157, and the Courſe South 32d. Weſt.

Geometrical Conſtruction.

Plate 8. *Fig.* 80. Draw the Line *a b c d* 157, and from *a* draw *a e*, to make with *a d* an Angle of 16 Degrees (equal to half the given Courſe) alſo from *d* draw *d e* to make with *a d* an Angle of 45 (always) at *d*, and continue *d e* till it cut *a e* in *e*. From *e* let fall the Perpendicular *e c* upon the Line *a d*, divide *a e* into two equal Parts in *g*, and from *g* draw *g b* perpendicular to *a e*, and to cut *a d* any where, as in *b*, and draw *b e*, and the Diagram as finiſhed.

Demonſtration.

The Triangles *a g b* and *e g b* are ſimilar, (*Euc. Lib.* 1. *Prob.* 24.) becauſe *e g* is equal to *g a* by Conſtruction, and *g b* is common to both Triangles, and the Angles *e g b* and *a g b* are right; therefore *g a b* is equal to *g e b*, but both theſe Angles together, is equal to the Angle *e b c*, (*Euclid Lib.* 1. *Prob.* 32.) and ſince the Angle *a e d* (*g a b*) is half the given Courſe by Conſtruction; *e b c* is the true Courſe, and conſequently *e b* equal to

b a

b a the true Diſtance, and becauſe *c d* is the Remainder of the whole Line that includes all the three, the Departure muſt be equal to it, and therefore the Line *d e* is drawn at an Angle of 45 with *d a* (*d c*) becauſe *e c* is to be equal to *c d*, and then is *a b* proved equal to *b e*, and *b c* is the Difference of Latitude in the Queſtion: Alſo *e c* is equal to *c d*, becauſe their oppoſite Angles are equal: Therefore the three Sides of the Triangles *b c e* is equal to the whole Line *a d*, and the Angle *e b c* is equal to the given Courſe 32 Degrees, which was to be demonſtrated.

Arithmetical Calculation.

We may obſerve, that the Angle *g e b* equal to *g a b*, is half the Courſe, and *b e c* is the Complement of the Courſe, and *c e d* is an Angle of 45 Degrees, and theſe three include the whole Angle *a e d* in the Triangle *a e d*, from whence we may deduce this general Proportion, for all Queſtions of this Data.

Add half the Courſe, the Complement of the Courſe, and 45 Degrees together, and ſay,

As the Sine of thoſe three Sums, to the Sum of the three Sides; ſo the Sine of half the Courſe, to a fourth Term. And as Radius, to that fourth Term, ſo Sine of 45 to the Departure.

The Courſe being given, and the Departure thus found, the reſt may be obtained by the Common Caſes of Plane Sailing.

Example in the preſent Queſtion.

	d.	m.
Half the Courſe *g e b* equal to *g a b* ——	16	0.
Complement of the Courſe *b e c* ——	58	0.
Angle *c e d* equal to *a e d* —— ——	45	0.
Sum is the whole Angle *a e d* —— ——	119	0.

Then,

		Co. Ar.
As Sine of *a e d*	119d. om.	0.05818
To Side oppoſite *a d*	157	2.19590
So Sine of the Angle *a*	16.0	9.44033
To Side oppoſite *e d*	94.5	1.69441

Then in the Triangle e c d.

As Radius		10.00000
To *e d*	49.5	1.69441
So Sine of *e d c*	45.0	9.84948
To Departure *e c*	35	1.54389

In the Triangle *e b c* is given the Courſe *e b c* 32d. om. and the Departure *e c* 35, to find the Diſtance *b e*.

As Sine of the Courſe	32d. om.	9.72421
To Departure	35	1.54389
So Radius		10.00000
To the Diſtance *b e*	66	1.81968

For the Difference of Latitude.

As Radius		10.00000
To the Diſtance	66	1.81968
So Sine Comp. of Courſe	58d. om.	9.92842
To Diff. Latitude	56	1.74810

Diſtance	66
Diff. Lat.	56
Departure	35
Sum	157 as was firſt given

From

From what hath been ſaid, we may reduce a general Rule for ſolving all Queſtions, whether in Right-angled, or Oblique Triangles, where the three Sides in one Sum is given, and the Angles alſo are given, *viz.*

Draw a Line of Length equal to the three Sides in one Sum, and from one End thereof, draw a Line to make with the former, an Angle equal to half of any of the given Angles; alſo from the other End, draw a Line to make with the firſt an Angle equal to half of another of the given Angles; continue theſe Lines till they interſect each other, then for the Middle of each, draw a Perpendicular to cut the firſt Line, then Lines drawn from the Interſection of the Perpendiculars to the firſt Line, to the Interſection of the two Lines, drawn from the End of the firſt, ſhall form the Triangle required, whether Right-angled or Oblique.

Example.

Queſtion the Eighth.

There is an Oblique Triangle, whoſe three Sides in one Sum is 120, and the three Angles are 40, 60, and 80, the Sides are required ſeparately.

Geometrical Conſtruction.

Draw the Line *a d* 120, the Sum of the Sides, and from *a* draw *a f*, to make with *a d* an Angle of 30 Degrees, *viz.* half the Angle 60, and from *d* draw *d f*, to make with *d a* an Angle of 40 Degrees, *viz.* half the Angle 80, continue *d f* till it cut *a f* in *f*; divide *f e* and *f a* equally in *e* and *g*, and draw the Perpendiculars *e c* and *g b*, to cut *a d* in *b* and *c*, from *b* draw *b f*, and from *c* draw *c f*, then is *b c f* the Triangle required. *Plate* 8. *Fig.* 81.

Demonſtration.

For *f c b* is double to *f c d*, becauſe equal to *c f e* and *c d e* together (*Euclid Lib.* 1. *Prob.* 32.) and *c f e*

is equal to *c d e*, becauſe their oppoſite Sides are equal; but *f d c* is 40 Degrees by Conſtruction, therefore *f c b* is 80 Degrees. By the ſame Rule *f b c* is 60 Degrees, becauſe *f a b* is 30 by Conſtruction; therefore *b f e* is 40 (*Euclid Lib.* 1. *Prob.* 32.) and becauſe *a b* is equal to *b f*, and *c d* equal to *c f*; therefore *b c*, *c f* and *f b* taken together, will be equal to the Line *a d*; and *b f c* is the Triangle required.

Arithmetical Calculation.

Hence as the Sine of one Angle, added to half the other two, to the Sum of the three Sides; ſo half one of the other Angles to a fourth Term: Then as the Supplement of the other Angle to 180, to that fourth Term, ſo Sine of half the ſaid Angle, to the Side next it.

Example.

The Angle *a f b* is half *f b c*, becauſe *f a b* is half *f b c* by Conſtruction; and *a f b* is equal to *f a b*, becauſe their oppoſite Sides are equal, and for the ſame Reaſon *c f d* is half *f c b*; but *a f b* with *b f c* and *c f d* make the whole Angle *a f d*; then a Sine of *a f d* to Side *a d* (the three Sides in one Sum) ſo Sine of *f a d* 30, (becauſe half of *f b c* by Conſtruction) to the Side *f d*; then as Sine of *f c d* (the Supplement of *f c b* to 180) to *f d*, ſo Sine of *f d c* 40 Degrees to the Side *f c*, which being found the reſt are alſo eaſily found.

Operation.

		Co. Ar.
As Sine of *a f d*	110d. 0m.	0.02701
To Side *a d*	120	2007918
So Sine of *f a d*	30.0	9.69897
To Side *f d*	63.8	1.80516

As

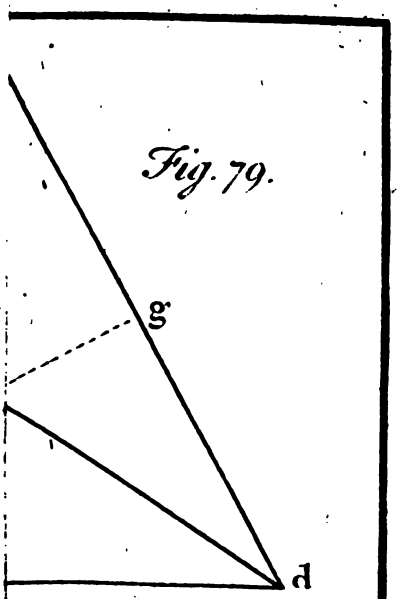


Fig. 79.

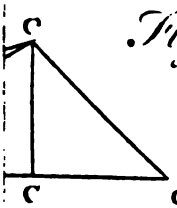


Fig. 80.

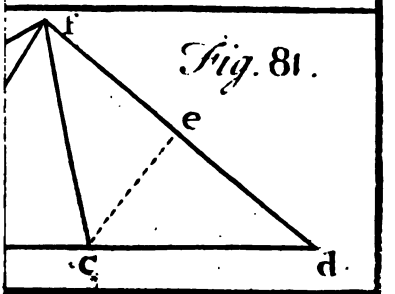


Fig. 81.

pag. 361.

			Co. Ar.
As Sine of *f c d*	100d. om.		0.00664
To Side *f d*	63.8		1.80516
So Sine of *f d c*	40.0		9.80806
To Side *f c*	41.7		1.61986

			Co. Ar.
As Sine of *f b c*	60d. om.		0.06247
To Side *f c*	41.7		1.61986
So Sine of *f c b*	80.0		9.99335
To Side *f b*	47.4		1.67568

			Co. Ar.
As Sine of *f b c*	60d. om.		0.06247
To Side *f c*	41.7		1.61986
So Sine *b f c*	40.0		9.80806
To Side *b c*	30.9		1.49039

The Side *f b*	47.4
The Side *f c*	41.7
The Side *b c*	30.9
Sum	120.0

The Sum 120, agreeing with what was given, serves as a Proof of the whole Work.

CHAP.

CHAP. X.

A

New and Exact Method

For finding the Longitude in any Place of the World, any Day at Noon, when the Sun can be ſeen, without any Regard to, or Dependance upon the Dead Reckoning.

THE often attempted, but never accompliſh'd, Work of finding the Longitude by an Obſervation is a Difficulty, which hath hitherto prov'd Inſuperable, even to the beſt Mathematicians in *England*, and elſewhere, although ſince the late Act of Parliament, many have exerted their utmoſt Induſtry for the attaining of that End, ſome of whom have been ſo far from compleating their intending Deſign, that they have on the other Hand, rather rendered themſelves and their Works rediculous, by publiſhing ſuch Improper and Improbable Me-

Methods, as a certain Artiſt (if he deſerves that Name) by certain fixed Stars choſen for each Time of the Year, *&c.*

Whereas it is evident, that any fixed Star ſhall come upon the Meridian of any Place, at (or near) the ſame Hour of the Day, that the ſame Star ſhall come upon the Meridian of *London*, although not at the ſame Inſtant of Time, but ſooner or later, 3, 4, 5, or 6 Hours, *&c.* according as the Place is more or leſs diſtant Eaſt or Weſt from the Meridian of *London*: But if there be that Difference in Hours as to the Time of a Star's coming upon theſe two different Meridians, there is alſo the ſame Difference in Hours between the Time of the Day or Night at *London*, and that under that Meridian; a South Sun in both Places making 12 o'Clock; and 'tis very evident that at the ſame Time of the Day or Night, that the Star comes upon the Meridian of *London*, it ſhall be the ſame Time of the Day or Night under any other Meridian, when the Star comes upon that Meridian, excepting ſo much as the Sun's Right Aſcenſion is increaſed in the Time of the Sun's paſſing from one Meridian to the other, which will cauſe the Star to come ſo much ſooner upon a Weſterly Meridian that upon an Eaſterly: But this being ſo little, being but about 4 Minutes of Time in 24 Hours, or 360 Degrees of Longitude, and but 1 Minute of Time in 90 Degrees, it is imperceptible; and yet (that ſmall Allowance excepted) there is no Difference between the Hour of any fixed Star's coming to the Meridian of *London*, and the Hour of the ſame Star's coming upon any other Meridian, becauſe the Sun's Motion makes the Hour of the Day, and the Star muſt needs come upon the Meridian the ſame Quantity of Time after the Sun in both Places. Indeed, if we could certainly know what Time of the *Day* or *Night* it is at *London*, when the Sun or any known Star is upon the Meridian of any other diſtant Place, the Longitude might be eaſily and exactly found; in order to which let the Maſter provide a good Glaſs, which may run exactly 24 Hours, or rather a good Watch, that hath been obſerv'd aſhore, to keep a true and equal Motion, this Watch ſet to the Time of Day

when

when you depart from any known Meridian, and kept going, will ſhew the Difference of Longitude, that you make whether Eaſt or Weſt; for Examples, if you ſail Weſtwards, obſerve juſt when the Sun is upon the Meridian, and ſee what Hour and Minute it is by your Watch, (which if you ſail Weſtward it will be paſt 12) for theſe Hours and Minutes which the Watch is paſt 12, when the Sun is upon the Meridian reduced to Degrees and Minutes of the Equator, allowing 15 Degrees to one Hour, and one Degree to every 4 Minutes of Time, and 15 Minutes of Longitude to one Minute of Time, ſhall ſhew the true Difference of Longitude.

Note; If you ſail Eaſtward, your Watch will want ſomething of 12 a Clock, when the Sun is upon the Meridian, becauſe then you meet the Sun, and have him upon your Meridian, before he comes upon the Meridian of *London*; in this Caſe obſerve how much your Watch wants of 12 a Clock, and that reduc'd as before, gives your Difference of Longitude Eaſterly: This in general is the Method that I ſhall recommend to the World for this End.

But I know it will be preſently objected, that this is no new Thing, nor is it practicable at Sea; for ſome that have attempted to keep ſome Account of their Longitude this Way, have found themſelves in an Error, not finding the Difference between the Watch and the Sun, when reduc'd as above, to give the Difference of Longitude which they were (for ſome Reaſons) pretty confident they had made, and this Error they impute to the Watch, and hence have inferred, That a Watch will not go ſo truly and regularly at Sea as on Shore, by reaſon of the ſalt moiſt Air that impedes its Motion or makes it uncertain, according to the Variableneſs of the Weather, and thereby renders this Method for finding the Longitude impracticable.

I anſwer, I do not believe at all that this Error is to be imputed to the Watch, if carefully kept, which you

you may eaſily do, if you provide a little ſquare or round Box about four or five Inches broad, and have it fill'd with fine Cotton, taking Part of the Cotton out, and putting the Watch towards the Middle of the Box upon the Cotton you leave in the Box, and put the reſt that you took out upon the Watch, and ſhut the Box, keeping it in ſome dry Place, as in your Cabbin, or upon ſome Shelf near your Bed: I queſtion not but a good Watch ſo kept would go as true at Sea as a-ſhore.

But I ſuppoſe the Error which hath been obſerv'd, and which hath cauſed them to deſiſt from making any Attempts to find the Longitude this Way, is for Want of a right Underſtanding of the Equation of Time, without which it is impoſſible to keep a good Watch right, or to ſuppoſe it is to be ſo either at Sea or a-ſhore, for a good Watch, (or Clock) divides the Time equally, but the Sun, by Reaſon of ſome Inequalities in his Motion divides the Time unequally; ſo that if the Sun and a true Watch be ſet together at ſome Times in the Year, yet the Watch will at other Times differ 10, 12, yea, ſometimes 16 Minutes from the Time given by the Sun, and yet no Fault in the Watch, and therefore it is very evident that if for finding the Longitude you only obſerve the Time of the Day given by the Watch, without regarding this Equation, eſpecially when the Equation is great, as 15 or 16 Minutes, you will be ſo much wrong in your Account of Longitude, as that 15 or 16 Minutes reduc'd to the Equator amounts to, *viz.* about 4 Degrees of Longitude, which is an intolerable Error, and might be prevented by allowing for the Equation of Time.

For further Illuſtration hereof, ſuppoſe you ſet your Watch with the Sun the 17th Day of *June*, then the Equation is nothing, being in *London* at the ſame Time, and continue there 'till the 3d Day of *November*, you will find your Watch to be got 16 Minutes behind the Sun, from hence (if you do not know to the contrary) you might by the foregoing Rule conclude that you had

altered

altered your Longitude 4 Degrees Eaſterly, but if to the Time given by the Watch, you add the Equation 16 Min. the Sum is the true Time of the Day by the Sun, and proving you to be in the ſame Meridian that you were under, when you ſet your Watch to the Sun, the Difference in Time, and conſequently the Difference of Longitude being nothing at all.

A TABLE

A TABLE of the *Equation of Time.*

Days	*Jan*		*Feb.*		*March*		*April*		*May*		*June*	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	4	14	14	15	12	47	3	58	3	14	2	56
2	4	42	14	22	12	35	3	40	3	22	2	48
3	5	9	14	28	12	22	3	22	3	30	2	39
4	5	36	14	34	12	8	3	3	3	37	2	29
5	6	4	14	38	11	54	2	45	3	43	2	16
6	6	30	14	42	11	40	2	26	3	49	2	9
7	6	67	14	45	11	24	2	9	3	53	1	59
8	7	24	14	47	11	9	1	51	3	57	1	48
9	7	48	14	48	10	54	1	34	4	1	1	37
10	8	12	14	49	10	38	1	17	4	4	1	25
11	8	37	14	49	10	21	1	1	4	7	1	14
12	9	4	14	48	10	4	0	45	4	10	1	2
13	9	26	14	46	9	47	0	28	4	11	0	50
14	9	48	14	44	9	30	0	12	4	12	0	37
15	10	10	14	41	9	13	0	3	4	13	0	25
16	10	31	14	37	8	55	0	11	4	12	0	13
17	10	50	14	32	8	37	0	33	4	11	0	0
18	11	9	14	27	8	19	0	48	4	10	0	13
19	11	27	14	21	8	1	1	2	4	8	0	26
20	11	45	14	15	7	43	1	16	4	6	0	39
21	12	2	14	7	7	25	1	28	4	3	0	52
22	12	18	13	59	7	6	1	41	4	0	1	4
23	12	34	13	50	6	47	1	54	3	56	1	17
24	12	47	13	41	6	28	2	6	3	51	1	30
25	13	2	13	31	6	10	2	16	3	46	1	43
26	13	15	13	21	5	51	2	27	3	40	1	56
27	13	27	13	10	5	32	2	38	3	34	2	8
28	13	38	12	59	5	14	2	48	3	28	2	20
29	13	48			4	55	2	57	3	21	2	32
30	13	58			4	36	3	6	3	13	2	44
31	14	7			4	17			3	5		

Watch too Fast

Too Fast

Too Fast

Too Fast

Too Slow

Too Slow

Too Slow

Too Fast.

A TABLE of the *Equation of Time.*

Days	*July*		*Auguſt*		*Sept.*		*October*		*Novem.*		*Decem.*	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	2	56	5	38	0	18	10	16	17	59	10	20
2	3	7	5	34	0	36	10	34	16	1	9	56
3	3	19	5	30	0	55	10	52	16	0	9	32
4	3	30	5	26	1	14	11	10	15	59	9	8
5	3	41	5	20	1	34	11	28	15	57	8	43
6	3	51	5	14	1	53	11	45	15	54	8	17
7	4	1	5	8	2	12	12	2	15	51	7	51
8	4	11	5	2	2	32	12	18	15	47	7	25
9	4	21	4	52	2	52	12	33	15	41	6	59
10	4	22	4	46	3	13	12	49	15	35	6	39
11	4	37	4	37	3	33	13	4	15	29	6	3
12	4	45	4	28	3	53	13	18	15	21	Too Slow 5	35
13	4	53	4	18	4	14	13	32	15	13	5	6
14	5	0	4	8	4	34	13	46	15	3	4	38
15	5	7	Too Fast 3	57	Too Slow 4	55	Too Slow 13	59	Too Slow 14	53	4	9
16	5	13	3	47	5	15	14	11	14	41	3	40
17	5	18	3	37	5	36	14	23	14	29	3	10
18	5	24	3	37	5	56	14	34	14	17	2	40
19	5	29	3	8	6	17	14	44	14	3	2	10
20	5	33	2	55	6	38	14	54	13	49	1	40
21	5	36	2	42	6	38	15	4	13	34	1	11
22	5	39	2	27	7	19	15	13	13	17	0	41
23	5	42	2	13	7	39	15	22	13	0	0	11
24	5	44	1	58	7	52	15	28	12	43	0	19
25	5	45	1	42	8	12	15	34	12	24	0	49
26	5	46	1	26	8	38	15	40	12	5	1	19
27	5	46	1	9	8	58	15	45	11	45	Too Fast 1	49
28	5	45	0	52	9	18	15	50	11	25	2	18
29	5	44	0	35	9	37	15	53	11	4	2	47
30	5	42	0	17	9	57	15	56	10	42	3	16
31	5	40	0	1			15	58			3	45

This

This Equation of Time is cauſed by an Inequality of the Sun's Motion from Weſt to Eaſt, according to the Succeſſion of Signs; for the ſwifter that the Sun is in his Annual Motion from Weſt to Eaſt, the ſlower he muſt be in his diurnal Motion from Eaſt to Weſt, as in plain by the Figure.

Suppoſe the Wheel A B C D E F to move round upon the Center G, once in 23 Hours, according to the Order of the Letters ABC, *Plate 9. Fig. 78. &c.* and in the ſame Quantity of Time, *viz.* 23 Hours, a Snail creeps the contrary Way, from A to F; now although the Point A is come to the Place where it was, having gone once about, yet the Snail wants the Space F A of a whole Revolution, and will not be got to the Top where A is, 'till A be got ſo far as the Point *q*, which will be about another Hour, and if the Snail had moved yet faſter, ſo that in 23 Hours ſhe had got from A to E, ſhe would have been yet ſo much longer in arriving at the Top, *viz.* about 25 Hours; from hence it is plain that the faſter the Snail creeps from A towards E, F, *&c.* the longer ſhe is in coming to the Top of the Wheel moving the contrary Way, and conſequently the faſter the Sun moves from Weſt to Eaſt in his Annual Motion according to the Succeſſion of Signs, the longer he is in making one Diurnal Revolution; and although the Sun's Revolution from the Meridian to the ſame Meridian again always determines the 24 Hours, yet it is plain from hence that every 24 Hours, by the Sun is not exactly the ſame equal Space of Time, which in Proceſs of Time makes a ſmall Difference between the Sun and a good Watch, and is the Occaſion of the aforeſaid Equation of Time.

This Inequality of the Sun's Motion proceeds from a Two-fold Cauſe.

The firſt Cauſe is the Obliquity of the Ecliptick, making an Angle with the Equator of 23d.—30m. or thereabouts; now the Ecliptic being properly an Ob-

lique Circle, the Poles of the Equator, and not of the Ecliptic, being the Poles of the World, and the Center of all Diurnal Motion, the Right Aſcenſion of the Sun muſt be accounted upon the Equator: And hence it is manifeſt, that although the Motion of the Sun in the Ecliptic were always equal, yet this Motion from Weſt to Eaſt, or his Right Aſcenſion accounted upon the Equator, could not be ſo much, or Increaſe ſo faſt in *Aries* or *Libra*, where the Ecliptic makes an Angle of 23 deg. 30 min. with the Equator, as in *Cancer* and *Capricorn*, where the Sun's Way in the Ecliptic is Parallel to the Equator.

Plate 9. *Fig.* 79. For Illuſtration of what has been ſaid, ſuppoſe the Line ABCD to repreſent half the Equator, and the Arch AFED, to repreſent half of the Ecliptic, now although the Segments A F and F E, and E D are equal, yet Perpendiculars let fall from the Points F and E upon the Line ABCD, at the Points B and C do not divide that Line into three Equal Parts, from whence it is plain, that the Sun's Right Aſcenſion D C is not ſo much increaſed by his running from D to E at ſo great an Obliquity to the Equator as the Sun's Right Aſcenſion CB is in his running from E to F, where his Motion is almoſt Parallel to the Equator; and then if his Motion is almoſt Parallel to the Equator; and then if his for Reaſon now given, his Diurnal Motion muſt be ſlower by the firſt Demonſtration.

But a ſecond Cauſe of this Inequality is ocoaſioned by the Eccentricity of the Sun's Orb (whether we allow the Sun or Earth the Motion, it matters not, but in this Caſe we ſhall impute the Motion to the Sun) which moves in his Orb ſometimes nearer, ſometimes farther off from the Earth, by which Means, although the Sun's Motion in his Orb were always equal, yet it would appear to us to be ſometimes ſwifter than at other times from Weſt to Eaſt, and conſequently ſlower in his Diurnal Motion, as you ſee demonſtrated in the following Figure.

Plate 9. *Fig.* 80.

In this Diagram ſuppoſe the Earth at the Center, about which is deſcribed the Circle A B C D, which is equally divided into 12 Parts, at the Points A. 1, 2. B. 3, 4, *&c.* repreſenting the 12 Signs which in themſelves are equally divided. Now if the Sun moved in the Circle A B C D, which is equally diſtant from the Earth its Center at E, his Motion would be regular and certain, but, the Earth being not the exact Center of the Sun's Orb, makes the Diviſion of the Signs although equal in themſelves, to appear unequal to us: For the Illuſtration of which, ſuppoſe the Sun to move in the uppermoſt Circle, marked ♈, ♉, ♊, &c. whoſe Center is at the Mark ☉, and ſuppoſe the Earth at the Center of the other Circle near the Mark E; now although with reſpect to the Center E, the Diviſions or Lines drawn from thence are equally diſtant, yet theſe Lines continued to the uppermoſt Circle in which the Sun is ſuppoſed to move, the Diviſions upon that Circle are very unequal, and therefore although the Sun's proper ſimple Motion ſhould be always equal, yet it is very plain that the Sun in Capricorn when neareſt the Earth, ſhall appear to us to run more ſwift, than when in Cancer, in his Aphelion or greateſt Diſtance from the Earth, by Reaſon of the ſmaller Diviſion of the Signs, not that they are really ſo, but appear ſo to us, becauſe of the Nearneſs of the Sun's Orb to the Earth, as you ſee the Points ♈ and ♎ are diametrically oppoſite to each other, ſuppoſing the Eye at the Center E, where the Earth is ſuppoſed to be, and the far greater Part of the Circle is above the Line ♈ ♎, which yet contains but ſix Signs, and the far leſſer Part is below that Line which contains alſo ſix Signs, and yet the Signs equally divided upon that Circle, whereof the Earth is ſuppoſed to be the Center.

Note; I am not here undertaking to determine whether the Sun or Earth be the Center of the World, or whether the Orbs of the Planets be Circular or Elip-

tical: for which Way ſoever it be, this Demonſtration ſerves to Illuſtrate what I am now upon, as to the Equation of Time; and to let the Reader ſee the Reaſon thereof, which is all that is expected from this Diagram.

Now the Occaſion of this Equation being Two-fold, as is proved, it is plain, that when both the Inequalities tends one Way, it alters the Equation faſter, as about the Middle of *December*, when the Sun is neareſt the Earth, he appears to move faſter from *Weſt* to *Eaſt* by the laſt Demonſtration; and alſo Running then almoſt parallel to the Equator, his Motion according to the Succeſſion of Signs, muſt be ſwift, by the ſecond Demonſtration; and therefore his Diurnal Motion or Revolution from Noon to Noon, muſt require more Time, by the firſt Demonſtration, and conſequently the Watches muſt now go faſter than the Sun; but in *June*, although that Part of the Ecliptick in which he is then, lies nearly parallel to the Equator, as in *December*, thereby accelerating his *Eaſterly* Motion, to our Appearance; yet his Diſtance from the Earth being then in *Aphelion*, helps to retard it, ſo that the Motion of the Equation, is not then ſo evident.

From this Inequality, as grounded by theſe Two Occaſions, are the foregoing Tables of Equation of Time calculated, which will ſerve for many Years, without any ſenſible Alteration. Their Uſe is ſo plain, that every Body may underſtand it; for find the Month at the Top of the Leaf, and the Day at the Left-hand, and in the common Angle of Meeting, you have the Equation in Minutes and Seconds, whether it be too faſt or too ſlow; as the Title [Watch too faſt] or [Watch too ſlow] directs.

And now for the Application hereof to the finding the Longitude: When you ſet Sail, obſerve in your Table of Equation of Time, how much the Watch is too Faſt or too Slow, and ſet your Watch to it, and not exactly to the Time of the Day, unleſs it be when the Equation is Nothing. As for Example, Suppoſe

poſe I am bound upon a Voyage any Day, when the Equation found in the Table is Seven Minutes, and the Title [Watch too ſlow] I conclude from thence, That a good Watch ſhould be ſeven Minutes too ſlow, or behind the Time given by a true Sun-Dial, therefore I put my Watch Seven Minutes behind Time given by the Sun. As, Suppoſe I ſet my Watch at 12 a Clock, I put it to 53 Minutes paſt 11, or if I ſet it at 4, I put it to 53 Minutes paſt 3, *&c.* and laying it carefully by, as before directed, it is fit for the Voyage.

Suppoſe I have ſail'd ſeveral Days to the *Weſtward* of the Meridian departed from, but whether *Northwards* or *Southwards* it matters not, finding the Sun juſt upon the Meridian I look at my Watch, and find it 16 Minutes paſt 3 o'Clock, and looking in the Equation Table, I find *Watch too faſt* 12 Minutes, therefore I ſubtract 12 Minutes from the Time given by the Watch, 3 Hours 16 Minutes, the Remainder 3 Hours 4 Minutes, reduced as before directed, gives 46 Deg. 0 Min. The true Difference of Longitude; but if it had been too ſlow 12 Min. you muſt have added 12 min. to 3 h. 16m. *&c.*

Note; If you ſet your Watch exactly with the Sun when the Equation is nothing, it will always after that hold the ſame Equation found in the Table, whether too faſt or too ſlow, and the ſame Quantity, (if your Watch go right) and that is the Reaſon, that if you ſet your Watch when there is Equation, you muſt give it the Equation anſwering to that Day, (whether ſwift or ſlow) and then it will alſo hold the ſame Equation.

If any Body will object, that if a Watch proves wrong and erroneous, it may cauſe a great Error to be contracted in this Way of finding the Longitude according to the Slowneſs or Swiftneſs of the Watch.

I anſwer, That I agree too; but nevertheleſs when Watches, as well as other Inſtruments, are made by a

good Workman, and ſold to a Gentleman for good and ſubſtantial, it is commonly expected that they ſhould anſwer the End for which they are made and bought; and if we will ſuffer this Objection to prevail yet farther, I anſwer, that with Reſpect to the Latitude it may as well be urged, that if our Quadrants, Fore-ſtaves, or other Inſtruments for that Purpoſe were made wrong, we ſhould be much deceived in our Obſervations for the Latitude, and yet how few upon ſuch Suppoſitions will fooliſhly deſiſt from the Uſe of thoſe Inſtruments for attaining the Latitude; nay, ſo far are they from that, that when they find an apparent Fault in a Quadrant, they will obſerve carefully what the Fault is, whether Northerly or Southerly, and how much, thereby, to regulate their future Obſervations; and when all is done, you ſhall rarely find whether they are many Quadrants, or many Obſervers aboard of one and the ſame Ship, and Obſerving at one and the ſame Time, that all their Obſervations ſhall be exactly the ſame, but differ ſometimes 6, 8, 10, or 20 Minutes, or ſometimes more; and yet theſe Differences are thought tolerable, and the Mariners continue to uſe theſe Means, and in a great Meaſure to truſt to them notwithſtanding; for we muſt not expect to attain to Infalibility in any Reſpect, whilſt we are traverſing this Terraqueous Globe ——— Not that I would adviſe any Body to be too credulous, or to take either Watches, or other Inſtruments, and truſt to them as the beſt, meerly upon the Report of another, unleſs you know you have great Reaſon to depend upon the Credit of them that ſo recommend them: But if you think to make uſe of this Method for finding the Longitude at Sea, take a Watch along with you, that you have had ſome Experience of aſhore, and if you have found that your Watch has gone well aſhore, and yet fear, that for the Reaſon before mentioned ſhe may not go ſo well at Sea, take her along with you upon ſome ſhort Coaſt Voyage, where you can every now and then obſerve whether ſhe keeps her true Motion at Sea as well as aſhore, and if you find

find that notwithſtanding your keeping her ſo carefully, as before directed, their Clammineſs of the Sea-Air, does (as ſome ſuppoſe) retard her Motion, you may uſe Means to quicken her Motion as much as to counterballance her Dulneſs occaſioned by the Sea-Air, if any ſuch Thing be, (which I cannot believe, if ſhe be kept warm and dry, as before directed) and by this Means I do not Queſtion but that this Method for finding the Longitude might be render'd as eaſy and practicable as the common Methods now in Uſe, for finding the Latitude by Obſervation, a Thing very deſirable, and therefore deſerves to be encouraged, and put in Practice.

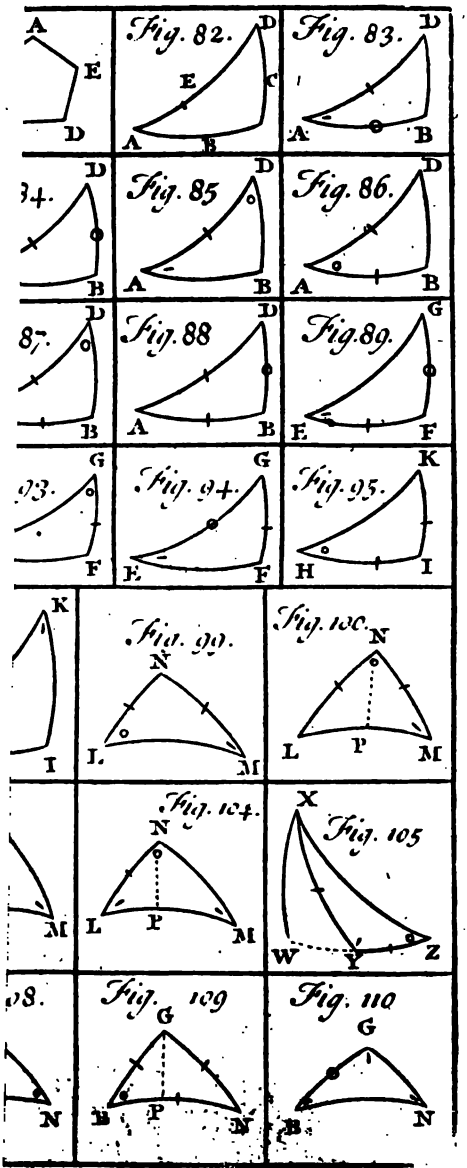
I know it is argued by Sailors, (and with good Reaſon too) that in Places near the Equinoctial, the Degrees of Latitude and Longitude are ſo nearly equal, and that the Mercator's Chart and Plain Chart, are ſo much alike, that Longitude there need not be much regarded; but the greateſt Neceſſity for it, and Difficulty in attaining it, it is in all Places nearer the Pole, eſpecially above 60 Degrees of Latitude, where a Degree of Longitude contains not half ſo many Miles as a Degree of Latitude, which makes the Work more difficult.

I anſwer, for the Encouragement of thoſe that would put in Practice what is here delivered, that the nearer the Poles that you come, and conſequently the leſſer the Degrees of Longitude are, the more practicable is this Method, and the leſs the Errors that can be ſuppoſed to be contracted; for in a few Miles Weſting or Eaſting in Latitudes above 60, where the Degrees of Longitude are not half ſo much as a Degree in the Equinoctial, you may much more ſenſibly and apparently diſcern your Difference of Longitude there than nearer the Equinoctial. I have been my ſelf running 5 or 6 Knots due Weſt in Latitude 72d. 30m. or thereabouts, (I do not exactly remember, but it was in coming from *Archangel*, about the North Cape of *Finmark*, the Cape itſelf lies in Latitude 71d. 22m. and we did not make the Cape coming Home) and in 24 Hours running, I could very ſenſibly diſcern that we

had gained about Half an Hour: So that when the Glaſſes were out for 12 a-Clock, (which we had formerly experienced to be very right) it wanted about half an Hour of 12 by the Sun, as near as I could compute, having no Help but the Ship's Glaſſes to compute it by: The Truth of which is alſo evident; for in Latitude 72d. 30m. there is but about 18 Miles to a Degree, and if we run about 135 Miles that 24 Hours, which might be done at the Rate aboveſaid, it would anſwer exactly to 7d.—30m. of Longitude, which is juſt half an Hour in Time; and hence it is plain, that the Difference of Longitude by this Method is more perceptable in great Latitudes than near the Equinoctial.

And that the Errors here contracted are alſo leſs, is as evident: For ſuppoſe your Watch to be wrong by 4 Minutes of Time, this 4 Minutes, I confeſs, is a Degree of Longitude in all Latitudes, and in that Reſpect the Error is equal in all Latitudes: But when the Longitude comes to be reduced to Miles, ſuch whereof 60 makes a Degree of a great Circle upon the Earth, you will find that a Degree at or near the Equinoctial, is about 60 Miles, and therefore an Error of 4 Minutes in Time begets an Error of 60 Miles near the Equinoctial; but in Latitude 72d. 30m. aforeſaid, where there is but 18 Miles to a Degree, an Error of 4 Minutes of Time begets an Error of but 18 Miles in Diſtance; and further North, where the attaining of Longitude is yet more difficult, the Errors contracted by this Operation will conſequently be leſs, an Error of 6 Leagues being as diſcernable in Latitude 72d. 30m. as an Error of 20 Leagues near the Equinoctial; ſo that although Sailing near the Equinoctial is commonly reckoned the eaſieſt in all other Caſes, yet by this Method the moſt difficult Caſes are become the moſt practicable and eaſy: And I think I may, without Preſumption, entitle it as uſeful an Help for finding the Longitude as what has yet been offered, and may be very aſſiſting in that uſeful Subject, till (if poſſibly) the deſired Compleatment thereof be accompliſhed.

Of


A
E
D
Fig. 82.
D
E
C
A
B
Fig. 83.
D
A
B
34.
D
B
Fig. 85
D
A
B
Fig. 86.
D
A
B
87.
D
B
Fig. 88
D
A
B
Fig. 89.
G
E
F
93.
G
F
Fig. 94.
G
E
F
Fig. 95.
K
H
I
K
I
Fig. 99.
N
L
M
Fig. 100.
N
L
P
M
M
Fig. 104.
N
L
P
M
X
Fig. 105
W
Y
Z
98.
N
Fig. 109
G
E
P
N
Fig. 110
G
E
N

UNIV. OF MICH.

Of *Aſtronomy.*

I HAVE in the former Part hereof, treated upon the Projection of the Sphere, and Spherical Trigonometry Right-angled and Oblique, which may ſerve as a good Introduction to this Chapter; in which I ſhall lay down all that Part of Aſtronomy, that is neceſſary in Navigation, and therewith conclude the Whole.

SECT. I.

Plate 10. *Fig.* 111.

Aſtronomical Definitions.

I ſhall bring the Definitions under theſe five Heads, 1. Points, 2. Great Circles, 3. Leſſer Circles, 4. Arches of Circles, 5. Angles.

1. *Points.*

The Zenith is the Point directly over our Heads as Z, and the Nadir is the Point oppoſite or directly under our Feet, as N.

The Poles of the Equator (commonly called the Poles of the World) are the North Pole P, and the South Pole S, and the Poles of any great Circle is every Way 90 Degrees diſtant from it, ſo the Poles of the Ecliptic Æ C are in the Point *c c*, &c.

2. *Great Circles.*

The Azimuths are great Circles, that interſect one another in the Zenith, and cut the Horizon at right Angles; ♈ ☉ R N and Z *d* N.

The

The Horizon is that great Circle, that divides the upper Hemiſphere from the lower, as H, A, O.

The Equator divides the North Hemiſphere from the South as E, Q, ——— the Ecliptic cuts the Equator at an Angle of 23, 30, as Æ C, the Prime Vertical is the Eaſt and Weſt Azimuth as ZAN.—— The Meridians are great Circles paſſing from Pole to Pole, as the Primitive P E S Q P, or the Right Circle P A S, or the Oblique Circle P ⊙ S, *&c.* The Meridians and Azimuths are infinite.

3. *Leſſer Circles.*

Leſſer Circles are commonly called Parallel Circles, becauſe they are generally Parallel to ſome great Circles; that the Parallel of Declination Æ ⊙ *f* is ſo called, becauſe it is Parallel to the Equinoctial; from whence the Declination is reckoned either North or South. ——— The Tropick of Cancer is a Parallel of Declination 23d. 30m. diſtant from the Equator Northward, and the Tropick of Capricorn at the ſame Diſtance Southward from the Equator.

The Parallels of Altitude (by ſome called Almicanthers) are leſſer Circles Parallel to the Horizon, as *b* ⊙ *e*. The Artick Circle is Parallel to the Equator, diſtance from it 66d. 30m. Northwards, and the Antartick Circle in the ſame Diſtance Southward from the Equator. ——— The two Poles of the Ecliptick are in theſe two Circles.

Note; Arches of leſſer Circles are never made Parts of Triangles.

4. *Arches of great Circle.*

The Sun's Altitude is an Arch of an Azimuth comprehended between the Sun and the Horizon, as ⊙ R.

Sun's Azimuth is an Arch of the Horizon, that is contain'd between the Azimuth that the Sun is in, and the Meridian (North or South) thus H R is the Sun's Azimuth from the South: When the Sun is any

any where in the Azimuth Z ⊙ N whatever his Altitude be.

Sun's Amplitude is the Diſtance that the Sun riſeth or ſets from the Eaſt or Weſt, or if you will from the North or South, and is an Arch of the Horizon contained between the Point where the Parallel of Declination, that the Sun moves in, cuts the Horizon, and the Eaſt or Weſt, North or South Point of the Horizon; thus when the Sun moves in the Parallel Æ ⊙ *f*, it riſes at *d*, and the Arch A *d* is the Sun's Amplitude from the Eaſt or Weſt, and the Arch *d* O is the Amplitude from the North.

Note; The Sun's Amplitude is always of the ſame Denomination with the Declination, whether North or South.

Right Aſcenſion is an Arch of the Equator contained between the Beginning of *Aries*, and that Point of the Equator where the Sun's Meridian interſects it, as A T is the Sun's Right Aſcenſion when it is any where in the Meridian P ⊙ T S; but in Aſtronomical Operations, the Diſtance between the ſaid Interſection, and the neareſt Equinoctial Point is the Right Aſcenſion, and then it can never exceed 90 Degrees.

Aſcenſional Difference is an Arch of the Equator contained between that Point of the Equinoctial that riſes with the Sun, and that Point that comes to the Meridian with him; thus the Point A riſes with the Sun; but the Point *n* comes to the Meridian with him, therefore A *n* is the Aſcenſional Difference.

Oblique Aſcenſion is an Arch of the Equator contained between the next Equinoctial Point, and that Point of the Equator that riſes with the Sun, and is found by adding to the Right Aſcenſion, or ſubtracting from it the Aſcenſional Difference, the Sum or Remainder is the Oblique Aſcenſion required.

Longitude of the Sun is the Sun's Diſtance from the neareſt Equinoctial Point, accounted on the Ecliptic thus, A ⊙ is the Sun's Longitude.

Decli-

Declination is an Arch of the Meridian contained between the Sun and the Equinoctial as ☉ T——

Angles.

The Sun's greateſt Declination is the Angle that the Ecliptic makes with the Equator, as T A ☉, and is accounted 23d. 30m.

The Hour of the Day is the Angle that the Meridian of the Sun makes with the Meridian of the Place; thus the Angle Æ P ☉ is the Hour that it wants of, or is part of 12, accounting 15d. to an Hour, *&c.*

The Sun's Azimuth is the Angle at Z, that is made between the Azimuth that the Sun is in, and the North and South Azimuth or Meridian of the Place, as the Angle HZR is reckon'd from the South; but R Z A is reckon'd from Eaſt or Weſt.

The Sun's Amplitude is an Angle at Z, that the Azimuth, that interſects the Horizon where the Sun's Parallel of Declination interſects it makes with the Prime Vertical, if reckoned from the Eaſt to Weſt, as A Z *d*, or *d* Z O, if reckoned from the North.

Theſe Angles may alſo be reckoned as Arches of great Circles, as the Hour is an Arch of the Equator, the Azimuth and Amplitude are Arches of the Horizon, *&c.*

SECT. II.

Aſtronomy Rectangular.

ALthough moſt of the neceſſary Caſes in Aſtronomy may be repreſented by a Projection upon the Plane of the Meridian, which to a great many Learners ſeems moſt natural and intelligible; yet there are ſome Caſes eſpecially in Oblique, that cannot

not be projected upon that Plane, in which Caſes take this general Rule.

When there is given two Sides and an Angle, make a given Side upon the Primitive, and the given Angle at the Primitive; but if two Angles and a Side be given, make both the Angles at the Primitive; and then, if the given Side be contained between the given Angles, it will alſo fall upon the Primitive; but if not, it falls within; but when three Sides, or three Angles are given it matters not which Circle you make Primitive, ſo it be generally one of thoſe great Circles, an Arch of which is a Part of the Triangle, nor are you always obliged to have the given Triangle at the Primitive; but it may ſometimes be drawn within.

There is 12 Signs in the Zodiac, their Names and Characters are as follow.

♈ Aries, ♉ Taurus, ♊ Gemini, ♋ Cancer, ♌ Leo, ♍ Virgo, ♎ Libra, ♏ Scorpio, ♐ Sagittarius, ♑ Capricorn, ♒ Aquarius, ♓ Piſces.

Each Sign contains 30 Degrees, in all 360, the Number of Degrees in every great Circle.

Note, When it is not expreſs'd what Plane the Projection is upon, it is always ſuppoſed upon the Plane of the Meridian.

Note alſo, When any Problem is referr'd to, it means the Problems in Spherical Geometry, annex'd to the Stereographick Projection of the Sphere.

Problem I.

Plate 10. *Fig.* 112.

Given the Sun's Longitude and greateſt Declination, to find the preſent Declination.

Sun's Place ♊ 0d. 0m. or Longitude from the Beginning of ♈ 60, greateſt Declination 23d. 30m.

Draw the Primitive H Z O N, and croſs it with the Diameters Z N and H O, at Right Angles (which being to be done in all Caſes, I ſhall uſe the Contraction P C Q; for draw the Primitive Circle and croſs it with two Diameters at Right Angles) draw E C the Ecliptick at an Angle of 23, 30, at A by

Prob.

Prob. 3. ſet the Longitude 60 from A to ☉ by Prob. 5. and through ☉ draw the Circle Z ☉ B N by Prob. 1. then is A B ☉ the Triangle required.

Here is given the Hypotenuſe A ☉; the Longitude 60 0, and the Angle A the greateſt Declination 23 30, to find the Perpendicular B ☉, the preſent Declination by Caſe 2.

As Radius — — — — — — —			10.00000
To Sine of A ☉ the Longitude —	60	0	9.93753
So Sine of A the greateſt Dec. —	23	30	9.60070
To Sine of B ☉ the preſent Dec. —	20	12	9.53823

Problem 2.

Plate 10. *Fig.* 112.

Given as in Prob. 1. to find the Right Aſcenſion A B; here is given the Hypotenuſe and an Angle, to find the Leg adjacent to the given Angle by Caſe 1.

As Tang. Comp. A ☉ the Longit.	60	0	9.76144
To Radius — — — — — — —			10.00000
So Sine Comp. A the greateſt Dec. —	23	30	9.96240
To Tang. AB the Right Aſcenſion	57	48	10.20096

Problem 3.

Plate 10. *Fig.* 112.

Given the greateſt Declination 23 30, and preſent Declination 20 12, to find the Longitude.

P C Q let Æ Q be the Equator, draw E C as in Prob. 1. for the Ecliptic, and at 20 12 the preſent Declination, Diſtance from the Equotor, draw the Parallel *m* ☉ *n*, by Prob. 4, and throngh the Point where it cuts the Ecliptic as in ☉ draw the Circle Z ☉ N by Prob. 1; then is A ☉ B the Triangle required.

Here is given the Angle A, and Leg oppoſite B ☉, to find the Hypotenuſe A ☉, the Longitude, by Caſe 12.

As

As Sine of A the greateſt Dec. ——	23	30 ——	9.60070
To Sine of B ⊙ the preſent Dec.—	20	12 ——	9.53819
So Radius —— —— ——			10.00000
To Sine of A ⊙ the Longitude—	60	00 ——	9.93749

Problem 4.

Plate 10. *Fig.* 112.

Given the greateſt Declination 23 30, and preſent Declination 20 12, to find the Right Aſcenſion.

Projection as in Prob. 3. being the ſame Data, the Angle A and Leg oppoſite B ⊙ are given, to find the other Leg A B by Caſe 10.

As Radius —— — —— ——			10.00000
To Tang. B ⊙ the preſent Dec.—	20	12 ——	9.56576
So Tang. Comp. A greateſt Dec.—	23	30 ——	10.36170
To Sine AB Right Aſcenſion——	57	48 ——	9.92746

Problem 5.

Plate 10. *Fig.* 112.

Given the greateſt Declination 23 30, and Right Aſcenſion 57 48, to find the preſent Declination.

PCQ, and let Æ Q be the Equator, and draw E C the Ecliptic to make an Angle of 23 30 the greateſt Declination by Prob. 3, with the Equator ſet the Right Aſcenſion, 57 48, from A upon the Equator to B, by Prob. 5, and thro' the Points ZBN draw the Circle ZBN to cut the Ecliptic in the Point ⊙; then is A B ⊙ the Triangle required.

Here is given the Angle A, and Leg adjacent AB, to find the Leg oppſite B ⊙; by Caſe 7.

As Tang. Comp. A greateſt Dec.	23	30 ——	10.36170
To Radius —— —— ——		—	10.00000
So Sine A B Right Aſcenſion —	57	48 ——	9.92747
To Tang. B ⊙ preſent Dec. —	20	12 ——	9.56577

Prob.

Problem 6.

Plate 10. *Fig.* 112.

Given the greateſt Declination 23 30, and the Right Aſcenſion 57 48, to find the Longitude.

Projected as in Problem 5.

Here is given the Angle A, and Leg adjacent A B, to find the Hypotenuſe A ⊙, by Caſe 9.

As Tang. A B Right Aſcenſion ——	57 48 —	10.20084
To Radius ——	— — —	10.00000
So Sine Comp. A greateſt Dec. ——	23 30 —	9.96240
To Tang. Comp. A ⊙ the Longitude	60 00 —	9.76156

Problem 7.

Plate 10. *Fig.* 113.

Given the Latitude of the Place North, and Sun's Declination 20 North, to find the Aſcenſional Difference.

And alſo Sun riſe and ſet ——	—	Prob. 8.
Length of the Day and Night ——	—	—— 9
Sun's Amplitude ——	——	—— 10
What Hour Sun is due Eaſt or Weſt ——		—— 11
Sun's Altitude when Eaſt or Weſt ——		—— 12
Sun's Altitude at ſix. ——	—	—— 13
Sun's Azimuth at ſix. ——	—	—— 14

P C Q ſet the Latitude 50 from O to P, and from H to S, and draw P S for the Axis of the World, and at Right Angles thereto draw E Q the Equator, and at an Angle of 23 30 therewith draw E C the Ecliptic: draw the Parallel *a* ⊙ *b c d e* diſtant from the Equator 20d. the given Declination to cut the Ecliptic in ⊙, and through ⊙ draw the Meridian P ⊙ S, and the Azimuth Z ⊙ N; alſo through where the Parallel of Declination cuts the Prime Vertical, draw the Meridian P *b* S, and through *c*, the Point

Point where the Parallel of Latitude cuts the Axis PS, draw the Azimuth Z *c* N, and through the Point where the ſaid Parallel cuts the Horizon as at *d*, draw the Meridian P *d* S, and then in the Triangle A *d h* is given the Angle A, the Comp. of Latitude 40; the the Side *h d* the Declination to find AB the Aſcenſional Difference, by Caſe 10.

As Radius				10.00000
To Tang. of Latitude	50	00	—	10.07618
So Tang. of *h d* the Declin.	20	00	—	9.56106
To Sine of Aſcenſional Difference	25	42	—	9.63724

Prob. 8. *Plate* 10. *Fig.* 113.

To find by the Aſcenſional Difference, what Time the Sun Riſes and Sets.

The Aſcenſional Difference converted into Time (allowing 15 Degrees to an Hour, and one Degree to 4 Minutes of Time,) gives the Time that the Sun riſes before or ſets after 6 in the Summer, or riſes after and ſets before 6 in the Winter; and at that Rate the Aſcenſional Difference 25 42 makes 1 Hour 43 Min. which added to ſix makes 7 Hours 43 Min. the Time of the Sun's ſetting in North Declination, or riſing in South Declination; but ſubtracted from 6 it leaves 4 17 the Time of Sun's Riſing in North Declination, or ſetting in South, *&c.*

Note; Subtract the Sun's Riſing from 12, the Remainder is the Setting.

Prob. 9. *Plate* 10. *Fig.* 113.

To find the Length of the Day or Night.

Double the Time of Sun's Setting found by *Prob.* 8. it gives the Length of the Night; and double the Time of Sun's Riſing it gives the Length of the Day: Then when the Sun Riſes at 4 17, that doubled makes 8.34 the Length of the Night; but the ſetting at the ſame Time 7 43 doubled is 15 26 the Length of the Day.

Problem 10.

Plate 10. *Figure* 113.

To find the Sun's Amplitude.

In the Triangle A *h d* is given, the Angle A, the Complement of Latitude, and Side *h d* the Declination, to find A *d* the Amplitude from the Eaſt or Weſt, by Caſe 12.

As Sine A the Comp. Latitude	— 40 0	—	9.80807
To Sine of *h d* the Declination	— 20 0	—	9.53405
So Radius —— —— —— ——			10.00000
To Sine of A *d* the Amplitude	— 32 9	—	9.72598

Or the Amplitude from the North may be found in the Triangle *d* P O, where is given *d* P the Complement of Declination 70 0, and O P the Latitude 50, to find *d* O, by Caſe 6.

As Sine Comp. P O the Latitude	— 50 0	—	9.80807
To Radius —— —— —— —— ——			10.00000
So Sine Comp. P *d* the Comp. Decl.	70 0	—	9.53405
To Sine Comp. *d* O the Amplitude	57 51	—	9.72598

Problem 11.

Plate 10. *Figure* 113.

Given the Latitude 50 0, and Declination 20 00, to find what Time the Sun will be due Eaſt or Weſt.

In the Triangle A *m b* there is given *m b* the Declination, and the Angle A the Complement of Latitude, to find *m* A the Hour from 6, by Caſe 10.

As Radius —— —— —— —— ——			10.00000
To Tang. *m b* the Declination	— 20 00	—	9.56106
So Tang. Comp. A the Latitude	— 50 00	—	9.92381
To Sine A *m* the Hour from 6,	— 17 47	—	9.48487

Or

Or it may be done by the Quadrantal Triangle A P *b*, the Side AP being a Quadrant, and the Angle P the Hour from 6; and therein is given the Side P *b* the Complement of Declination 70 0; and the Angle *b* A P the Complement of Latitude 40 0 to find *b* P A: And here omitting the Quadrantal Side A P, the Angle P is middle Part, and A and *b* P are Conjuncts; therefore,

As Radius —— —— —— ——			10.00000
To Tang. A the Comp. Lat. —	40 00	—	9.92381
So Tang. Comp. *b* P —— —	70 00	—	9.56106
To Sine of P the Hour from 6, —	17 47	—	9.48487

Problem 12.

Plate 10. *Figure* 113.

To find the Sun's Altitude at 6 *o'Clock.*

The Sun is in the Point *c* at 6 o'Clock, and in the Triangle A *i c* there is given the Angle A the Latitude, and the Hypotenuſe A *c* the Declination, to find *i c* the Altitude at 6, by Caſe 2.

Problem 13.

Plate 10. *Figure* 113.

To find the Sun's Azimuth at 6 *o'Clock.*

This may be done either by the Right-angled Triangle A *i c*, where the Leg A *i* is the Azimuth at 6, or by the Quadrantal Triangle A *c* Z; where the Angle Z is the ſaid Azimuth, I ſhall only inſtance in the Quadrantal, and leave the other Operation of this and the laſt Problem for the Reader's Practice.

There is given A *c* the Declination, and the Angle Z A *c* the Complement of Latitude to find A Z *c* the Azimuth at 6.

Here A is middle Part, and the other two are Conjuncts; therefore,

As Tang. Comp. of A *c* the Declination	20.0 —	10.43893
To Radius —— —— —— ——		10.00000
So Sine of A the Comp. Latitude ——	40.0 —	9.80807
To Tang. of Z the Azimuth ——	13.10 —	9.36914

Problem 14.

Plate 10. *Figure* 113.

Given the Sun's Declination and Time of Riſing and Setting, to find the Amplitude.

Suppoſe the Sun riſes at 17m. paſt Four in the Morning, his Declination 20d. North, I demand the Amplitude.

In the Triangle *d* P O there is given the Angle P, the Hour paſt Midnight 4 Hours 17m. or reduced to Time 64d. 15m. and the Hypotenuſe *d* P the Complement of Declination to find the Leg *d* O, by Caſe 2.

As Radius —— —— —— ——		10.00000
To Sine of *d* P the Comp. Declination	70 0 —	9.97298
So Sine of P, the Hour from Midnight	64 15 —	9.95458
To Sine *d* O the Ampl. from North	57 49 —	9.92756

Or it may be found by the Quadrantal Triangle A *d* P, in which is given the Angle P, the Hour of Sun's Riſing before 6; and *d* P the Complement Declination to find A *d* the Amplitude from the Eaſt or Weſt.

By a right Underſtanding of the Nature of Spherical Triangles, the Latitude at Sea may be often attain'd in an Afternoon or Evening, when you cannot have an Obſervation at Noon; as in the Triangles A *i c*, you may by having the Declination A *c* and Amplitude A *i* given, find the Latitude the Angle at A, or, in the Triangle A *m b* you may by having A *b*, the Sun's Altitude, when Eaſt or Weſt, and *m b* the Declination given, find the Angle A the Complement of Latitude, &c. but ſhall leave this to the Reader's Induſtry.

Prob.

Problem 15.

Plate 10. *Figure* 114.

Given the Sun's Altitude, Declination and Latitude of the Place to find the Azimuth.

Latitude 54 40, Altitude 47 48, Declination 20.12.

C P Q, ſet the Latitude 54 40 from C to P, and draw P S, and at Right-Angles therewith draw E Q; for the Equator draw the Parallel of Altitude *c* ⊙ *d* at the given Altitude 40 48 above the Horizon, and alſo the Parallel of Declination *a* ⊙ *b* 20 12 from the Equator, and through the Interſection of theſe Parallels draw the Azimuth Z⊙N; and the Meridian P⊙S by Prob. 1. and then by the 11th Caſe of Oblique Spheric Triangles.

Comp. Latitude —— ——	Z P ——	35.20
Comp. Altitude —— ——	Z⊙ ——	42.12
Comp. Declination — ——	⊙ P ——	69.48
	Sum ——	147.20
	½Sum ——	73.40
Side oppoſite to the required Angle P⊙ ——		69.48
	Remains ——	3.52

Z P 35 20 Sine Co. Ar.— —— ——		0.23782
Z⊙ 25 12 Sine Co. Ar.— —— ——		0.17281
½ Sum of the Sides 73 40 Sine —— ——		9.98211
Diff. 3 52 Sine —— —— ——		8.82888
	Sum ——	19.22162
½ Sum is Sine Comp. of 65 55 —— ——		9.61081

Doubled is 131 50 the Azimuth required.

Problem 16.

Plate 10. *Figure* 115.

Given the Altitude, Declination and Hour, to find the Azimuth.

Altitude 47 48, Declination 20 12, and Hour or Angle at P 32 12.

P C Q and draw P ⊙ S, to make an Angle at 32 12 with the Primitive by Problem 3, and thereon ſet off the Complement of Declination 69 48 from P to ⊙ by Prob. 5; alſo draw the Parallel Z *a b c* diſtant from ⊙ 42 12 the Complement of Altitude, and it will cut the Primitive in Z; then through Z ⊙, and the oppoſite Point N draw the Oblique Circle Z ⊙ N, and the Triangle Z P ⊙ is finiſhed, and by Solution 7.

		Co. Ar.
As Sine Comp. of Altitude Z ⊙	42 12	0.17281
To Sine of the Hour Z P ⊙	32 12	9.72662
So Sine Comp. Declination ⊙ P	69 48	9.97243
To Sine of the Azimuth ⊙ Z P	48 7	9.87186

But being obtuſe it muſt be ſubtracted from 180, and the Remainder 131 53 is the Azimuth required.

The Truth of all your Calculations may be examined and proved by meaſuring the Side or Angle required by the Directions given, by Prob. 6, and 7. of Spherical Geometry, which would have been needleſs to repeat in all the foregoing Operations.

Problem 17.

Plate 10. *Figure* 113.

Given the Latitude, Azimuth, and Hour to find the Declination.

Latitude North,	54 40	to find the Sun's Declin. by Caſe the Ninth.
Azimuth,	131 52	
Hour,	32 12	

Here the Perpendicular muſt fall upon the Side ⊙ Z, continued, which for Illuſtration I have annexed to the Scheme; then in the Triangle Z *e* P, is given *e* Z P 48 8, and Z P 35 20, to find Z P *e*, by Caſe the Third of Right-angled Spherical Triangles.

As

As Tang. Comp. P Z *e*	48	8	9.95240
To Radius			10.00000
So Sine Comp. Z P	35	20	9.91158
To Tang. Comp. Z P *e*	47	41	9.95918

Then by Concluſion the Eighth.

As Sine Comp. *e* P ☉	79	53 Co. Ar.	0.75534
To Tang. P Z	35	20	9.85059
So Sine Comp. *e* P Z	47	41	9.82816
To Tang. P ☉	69	48	10.43409

To Complement of Declination being 69 48, the Declination required is 20 12,

Problem 18.

Plate 10. *Figure* 113.

Given the Azimuth, Hour, and Angle of Poſition, to find the Latitude.

Azimuth,	131 52	} to find the Latitude by Caſe the 11th.
Hour,	32 12	
Angle of Poſition,	27 19	

Take the Complement of the greateſt Angle, to 180, add that and the two leſſer Angles together, and from the half Sum ſubtract the Angle oppoſite to the Side required, and proceed as in Prob. 11.

EXAMPLE.

The greateſt Angle	131 52
Its Complement,	48 8
Angle Z P ☉,	32 12
Angle Z ☉ P,	27 19

Sum	107 : 39
Half Sum	53 : 49½
Angle oppoſite to Side required	27 : 19
Remainder	26 : 30½

⊙ Z P, Co. Ar.	0.12801
Z P ⊙, Co. Ar.	0.27337
Half Sum 53.49½	9.90699
Remainder	9.64965
	19.95802
Sine Comp. 17.40	2.97901

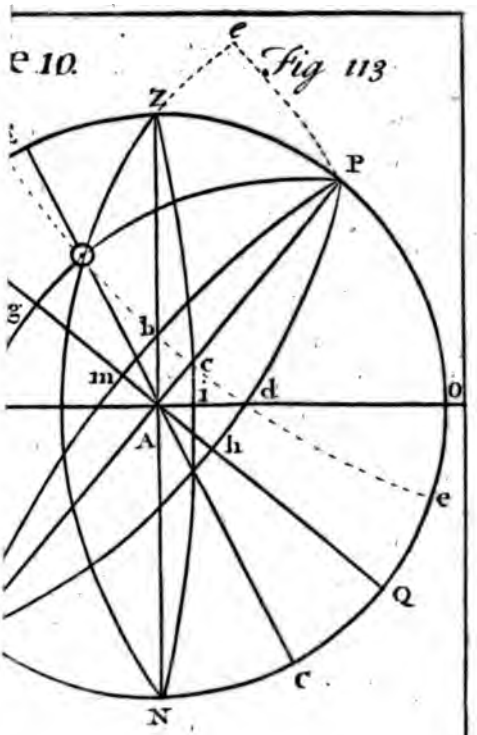
Doubled, is 35 20 the Latitude, or Side ZP required.

Thus much for the Application of Oblique Spherical Triangles in Queſtions of Aſtronomy.

N.B. *The Number* 57.3 *in Chap.* 6. *Page* 141. *has its Authority from its being the Semidiameter of a Circle whoſe Circumference in* 360 *the Degrees in a great Circle) and conſequently may be applied otherways to finding Angles than in Degrees only: This I thought fit to diſcover, leſt ſome Pamphletering Navigator ſhould aſſert it to be a fictitious and groundleſs Number, but ſhall defer any further Account of the Reaſon of the Steps in the Operation, leſt they ſhould catch it up and call it their own, as an Attempt was made upon my Method of finding the Longitude by a Right-angled Plane Triangle, Chap.* 6. *Sect.* 4. *only I produced it in the firſt Impreſſion of this Book, which was printed above ſeven Years before this upſtart Author's Copy was writ.*

e 10.

Fig 113



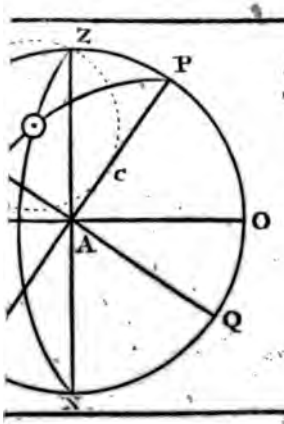


Fig.115.

A TABLE of the *Engliſh*, *Latin*, *Italian*, and *Spaniſh* Names of the Two and Thirty Points of the COMPASS.

Engliſh	Latin.	Italian.	Spaniſh.
North	*Septentrio*	*Tramontana*	*Norte*
N by E.	*Hypaquilo*	*4 di Tramontana Græco*	*Norte 4 a Nord' eſte*
N N E.	*Aquilo*	*Tramontana Græco*	*Nord Nord' eſte*
NE by N.	*Meſaquilo*	*4 di Græco Tramontana*	*Nord' eſte 4 a Norte*
N E.	*Borrapelioites*	*Græco*	*Nord' eſte*
NE by E.	*Hypoc.æſias*	*4 di Græco Levante*	*Nord' 4 al eſte*
E N E.	*Cæſias*	*Levante Græco*	*Les Nord' a eſte*
E by N.	*Moſocæſias*	*4 di Levante Græco*	*Les 4 a Nord' eſte*
Eaſt.	*Subſolanus*	*Levante*	*L' eſte*
E by S.	*Ypeurus*	*4 di Levante Sirocco*	*L' eſte 4 a Sueſte*
E S E.	*Eurus*	*Levante Sirocco*	*L' Sueſte*
SE by E.	*Meſurus*	*4 di Sirocco Levanto*	*Sueſte 4 al eſte*
S E.	*Notapelioſes*	*Sirocco*	*Sueſte*
SE by S.	*Hypophœnix*	*4 di Sirocco Oſtro*	*Sueſte 4 al Sur*
S S E.	*Phœnix*	*Oſtro Sirocco*	*Sur Sueſte*
S by E.	*Mæſophenix*	*4 di Oſtro Sirocco*	*Sur 4 a Sueſte*
South.	*Notus*	*Oſtro*	*Sur*
S by W.	*Meſolibanotus*	*4 di Oſtro Garbino*	*Sur 4 al Sudeſte*
S S W.	*Libabotus*	*Oſtro Garbino*	*Sud Sudeſte*
SW by S.	*Hypolibanotus*	*4 di Garbino Oſtro*	*Sud Veſt 4 al Sud*
S W.	*Notalybicus*	*Garbino o Libeccio*	*Sud Veſt*
SW by W.	*Meſufricus*	*4 di Garbino Ponente*	*Sud Veſt 4 al Oeſt*
W S W.	*Africus*	*Ponente Garbino*	*Oeſt Sud Oeſt*
W by S.	*Hypafricus*	*4 di Ponente Garbino*	*Oeſt 4 al Sudueſt*
Weſt.	*Zephyrus*	*Ponente*	*Oeſt*
W by N.	*Meſocorus*	*4 di Ponente Maeſtro*	*Oeſt 4 al Nord Oeſt*
W N W.	*Corus*	*Ponente Maeſtro*	*Oeſt Nord Oeſt*
NW by W.	*Hypocorus*	*4 di Maeſtro Ponente*	*Nord Oeſt 4 al Nort*
N W.	*Borrolybicus*	*Maeſtro*	*Nord Oeſt*
NW by N.	*Hypocircius*	*4 di Maeſtro Tramont*	*Nord Oeſte 4 a Nor*
N N W.	*Circius*	*Tramontana Maeſtro*	*Nor Nor Oſte*
N by W.	*Miſocircius*	*4 di Tramon Maeſtro*	*Nor 4 a Nor Oeſte*

The

The Variation of the Compaſs, as I obſerved it in the Year 1718, aboard of His Majeſty's Ship the *Barfleur*, under the Command of the Right Honourable Sir *George Byng*, Admiral of the Fleet

Variation Weſt D.	M.	*Bearings of Headlands*, &c.
10	53	*USHANT* Eaſterly.
8	52	Cape *Finiſter*, ENE. 12 Leagues.
8	7	Off of *Liſbon*, within ſight of Land.
8	55	St. *Jago*, NE. 14 Leagues.
8	45	Cape St. *Mary*, NNE. half E. 5 Leagues.
8	2	Cape St. *Mary*, NNW. 17 Leagues.
		Before *Straits-Mouth*, ſometimes without ſight of Land, we had by ſeveral good Obſervation 7 deg. or within ½ deg. more or leſs.
9	38	Cape *Palos*, 10 Leagues WSW.
14	31	*Cabrera*, (near *Majorca*) NW. 8 Leagues.
14	52	Eaſt Point of *Majorca*, WNW. 6 Leagues.
14	8	At Anchor before Port *Mahon*.
10	54	Cape *Tolar*, E. half S. 25 Leag. by Eſtimation.
17	16	Cape *Carbonera*, NW. half N. 7 Leagues.
13	44	Cape *Carbonera*, WNW. 9 or 10 Leagues.
11	48	Cape *Carbonera*, W. by S. 11 Leagues.
11	35	*Serpentaria*, W. by S. Cape *Gomera*, NW.
11	46	Entry *Naples* Bay.
10	50	Off of *Palinura*.
12	21	*Strombelo*, W. by S. 1 League.
11	30	Before *Syracuſe*.
11	45	Cape *Paſſero*, N. half W. 4 Leagues.
11	38	Before *Malta*.

Upon the South Cooſt of *Sicily*, it continued between 12 and 13 Degrees; but ſailing from *Palerma* to *Naples*, it decreaſed to 11.46 as obſerved in *Naples*-Bay.

N.B. It may be thought ſurprizing, that to the Weſtward of *Sardinia*, there ſhould be leſs than 11 Degrees, and South Eaſt from it is above 17. There is ſome Reaſon to believe, that there are ſome Magnetical Rocks, in or near that Iſland which may affect the Compaſs; but we muſt leave that to Time and further Experience to determine.

A TABLE of LOGARITHMS

For Numbers increasing in their Natural Order, from an Unit to 10,000.

With a Table of Artificial SINES, TANGENTS, and SECANTS, the RADIUS 10,000000; and to every Degree and Minute of the *Quadrant*.

N.	Logor.	N.	Logar.	N.	Logar.
1	0.000000	34	1.531479	67	1.826075
2	0.301030	35	1.544068	68	1.832509
3	0.477121	36	1.556302	69	1.838849
4	0.602060	37	1.568202	70	1.845098
5	0.698970	38	1.579784	71	1.851258
6	0.778151	39	1.591065	72	1.857332
7	0.845098	40	1.602060	73	1.863323
8	0.903090	41	1.612784	74	1.869232
9	0.954242	42	1.623249	75	1.875061
10	1.000000	43	1.633468	76	1.880814
11	1.041393	44	1.643453	77	1.886491
12	1.079181	45	1.653212	78	1.892095
13	1.113943	46	1.662758	79	1.897627
14	1.146128	47	1.672098	80	1.903090
15	1.176091	48	1.681241	81	1.908485
16	1.204120	49	1.690196	82	1.913814
17	1.230449	50	1.698970	83	1.919078
18	1.255272	51	1.707570	84	1.924279
19	1.278754	52	1.716003	85	1.929419
20	1.301030	53	1.724276	86	1.934498
21	1.322219	54	1.732394	87	1.939519
22	1.342423	55	1.740363	88	1.944483
23	1.361728	56	1.748188	89	1.949390
24	1.380211	57	1.755875	90	1.954242
25	1.397940	58	1.763428	91	1.959041
26	1.414973	59	1.770852	92	1.963788
27	1.431364	60	1.778151	93	1.968483
28	1.447158	61	1.785330	94	1.973128
29	1.462398	62	1.792392	95	1.977724
30	1.477121	63	1.799340	96	1.982271
31	1.491362	64	1.806180	97	1.986772
32	1.505150	65	1.812913	98	1.991226
33	1.518514	66	1.819544	99	1.995635

Num	0	1	2	3	4	Diff.
100	2.000000	2.000434	2.000868	2.001301	2.001734	432
101	2.004321	2.004751	2.005180	2.005609	2.006038	428
102	2.008600	2.009026	2.009451	2.009876	2.010300	424
103	2.012837	2.013256	2.013680	2.014100	2.014520	419
104	2.017033	2.017451	2.017868	2.018284	2.018700	416
105	2.021189	2.021603	2.022016	2.022428	2.022841	412
106	2.025306	2.025715	2.026124	2.026533	2.026942	408
107	2.029384	2.029789	2.030195	2.030600	2.031004	404
108	2.033424	2.033826	2.034227	2.034628	2.035029	400
109	2.037426	2.037825	2.038223	2.038620	2.039017	396
110	2.041393	2.041787	2.042182	2.042575	2.042969	393
111	2.045323	2.045714	2.046105	2.046495	2.046885	389
112	2.049218	2.049606	2.049993	2.050380	2.050766	386
113	2.053078	2.053463	2.053846	2.054230	2.054613	382
114	2.056905	2.057286	2.057666	2.058046	2.058426	379
115	2.060698	2.061075	2.061452	2.061829	2.062206	376
116	2.064458	2.064832	2.065206	2.065580	2.065953	372
117	2.068186	2.068557	2.068928	2.069298	2.069668	369
118	2.071882	2.072250	2.072617	2.072985	2.073352	366
119	2.075547	2.075912	2.076276	2.076640	2.077004	363
120	7.079181	2.079543	2.079904	2.080266	2.080626	360
121	2.082785	2.083144	2.083503	2.083861	2.084219	357
122	2.086360	2.086716	2.087071	2.087426	2.087781	355
123	2.089905	2.090258	2.090611	2.090963	2.091315	351
124	2.093422	2.093772	2.094122	2.094471	2.094820	349
125	2.096910	2.097257	2.097604	2.097951	2.098297	346
126	2.100370	2.100715	2.101059	2.101403	2.101747	343
127	2.103804	2.104145	2.104487	2.104828	2.105169	340
128	2.107210	2.107549	2.107888	2.108227	2.108565	338
129	2.110590	2.110926	2.111262	2.111598	2.111934	335
130	2.113943	2.114277	2.114611	2.114944	2.115278	333
131	2.117271	2.117603	2.117934	2.118265	2.118595	330
132	2.120574	2.120903	2.121231	2.121560	2.121888	328
133	2.123852	2.124178	2.124504	2.124830	2.125156	325
134	2.127105	2.127429	2.127752	2.128076	2.128399	323
135	2.130334	2.130655	2.130977	2.131298	2.131619	321
136	2.133539	2.133858	2.134177	2.134496	2.134814	318
137	2.136721	2.137037	2.137354	2.137670	2.137987	315
138	2.139879	2.140194	2.140508	2.140822	2.141136	314
139	2.143015	2.143327	2.143639	2.143951	2.144263	311
140	2.146128	2.146438	2.146748	2.147058	2.147367	309
141	2.149219	2.149527	2.149835	2.150142	2.150449	307
142	2.152288	2.152594	2.152900	2.153205	2.153510	305

Num	5	6	7	8	9	Diff.
100	2.002166	2.002598	2.003029	2.003467	2.003891	432
101	2.006466	2.006894	2.007321	2.007748	2.008174	428
102	2.010724	2.011147	2.011570	2.011993	2.012415	424
103	2.014940	2.015360	2.015779	2.016198	2.016615	419
104	2.019116	2.019532	2.019947	2.020361	2.020775	416
105	2.023252	2.023664	2.024075	2.024486	2.024896	412
106	2.027350	2.027757	2.028164	2.028571	2.028978	408
107	2.031408	2.031812	2.032216	2.032619	2.033021	404
108	2.035430	2.035830	2.036229	2.036629	2.037028	400
109	2.039414	2.039811	2.040207	2.040602	2.040998	396
110	2.043362	2.043755	2.044148	2.044540	2.044931	393
111	2.047275	2.047664	2.048053	2.048442	2.048830	389
112	2.051152	2.051538	2.051924	2.052309	2.052694	386
113	2.054996	2.055378	2.055760	2.056142	2.056524	382
114	2.058805	2.059185	2.059563	2.059942	2.060320	378
115	2.062582	2.062958	2.063333	2.063709	2.064083	376
116	2.066326	2.066699	2.067071	2.067443	2.067814	372
117	2.070038	2.070407	2.070776	2.071145	2.071514	369
118	2.073718	2.074085	2.074451	2.074816	2.075182	366
119	2.077368	2.077731	2.078094	2.078457	2.078819	363
120	2.080987	2.081347	2.081707	2.082067	2.082426	360
121	2.084576	2.084934	2.085291	2.085647	2.086004	357
122	2.088136	2.088490	2.088845	2.089198	2.089552	354
123	2.091667	2.092018	2.092370	2.092721	2.093071	351
124	2.095169	2.095518	2.095866	2.096215	2.096562	349
125	2.098644	2.098990	2.099335	2.099681	2.100026	346
126	2.102090	2.102434	2.102777	2.103119	2.103462	343
127	2.105510	2.105851	2.106191	2.106531	2.106870	340
128	2.108903	2.109241	2.109578	2.109916	2.110253	338
129	2.112270	2.112605	2.112940	2.113275	2.113609	335
130	2.115610	2.115943	2.116276	2.116608	2.116940	333
131	2.118926	2.119256	2.119586	2.119915	2.120245	330
132	2.122216	2.122543	2.122871	2.123198	2.123525	328
133	2.125481	2.125806	2.126131	2.126456	2.126781	325
134	2.128722	2.129045	2.129368	2.129690	2.130012	322
135	2.131939	2.132260	2.132580	2.132900	2.133219	320
136	2.135133	2.135451	2.135768	2.136086	2.136403	318
137	2.138303	2.138618	2.138934	2.139249	2.139564	315
138	2.141450	2.141763	2.142076	2.142389	2.142702	313
139	2.144574	2.144885	2.145196	2.145507	2.145818	311
140	2.147676	2.147985	2.148294	2.148603	2.148911	309
141	2.150756	2.151063	2.151370	2.151676	2.151982	306
142	2.153815	2.154119	2.154424	2.154728	2.155032	303

Num	0	1	2	3	4	Diff.
143	2.155336	2.155640	2.155943	2.156246	2.156549	303
144	2.158362	2.158664	2.158965	2.159266	2.159567	301
145	2.161368	2.161667	2.161967	2.162266	2.162564	299
146	2.164353	2.164650	2.164947	2.165244	2.165541	297
147	2.167317	2.167613	2.167908	2.168203	2.168497	295
148	2.170262	2.170555	2.170848	2.171141	2.171434	293
149	2.173186	2.173478	2.173768	2.174060	2.174351	291
150	2.176091	2.176381	2.176670	2.176959	2.177248	289
151	2.178977	2.179264	2.179552	2.179839	2.180126	287
152	2.181844	2.182129	2.182415	2.182700	2.182985	285
153	2.184691	2.184975	2.185259	2.185542	2.185825	283
154	2.187521	2.187803	2.188084	2.188366	2.188647	281
155	2.190332	2.190612	2.190892	2.191171	2.191451	279
156	2.193125	2.193403	2.193681	2.193959	2.194237	278
157	2.195900	2.196176	2.196452	2.196729	2.197005	276
158	2.198657	2.198932	2.199206	2.199481	2.199755	274
159	2.201397	2.201670	2.201943	2.202216	2.202488	272
160	2.204120	2.204391	2.204662	2.204933	2.205204	271
161	2.206826	2.207095	2.207365	2.207634	2.207903	269
162	2.209515	2.209783	2.210051	2.210318	2.210586	267
163	2.212188	2.212454	2.212720	2.212986	2.213252	266
164	2.214844	2.215109	2.215373	2.215638	2.215902	264
165	2.217484	2.217747	2.218010	2.218273	2.218535	262
166	2.220108	2.220370	2.220631	2.220892	2.221153	261
167	2.222716	2.222976	2.223236	2.223496	2.223755	259
168	2.225309	2.225568	2.225826	2.226084	2.226342	258
169	2 227887	2.228144	2.228400	2.228657	2.228913	256
170	2.230449	2.230704	2.230960	2.231215	2.231470	254
171	2.232996	2.233250	2.233504	2.233757	2.234011	253
172	2.235528	2.235781	2.236033	2.236285	2.236537	252
173	2.238046	2.238297	2.238548	2.238799	2 239049	250
174	2.240549	2.240799	2.241048	2.241297	2.241546	249
175	2.243038	2.243286	2.243534	2.243782	2.244030	248
176	2.245513	2.245759	2.246006	2.246252	2.246499	246
177	2.247973	2.248219	2.248464	2.248709	2.248954	245
178	2.250420	2.250664	2.250908	2.251151	2.251395	243
179	2.252853	2.253096	2.253338	2.253580	2.253822	242
180	2.255272	2.255514	2.255755	2.255996	2.256237	241
181	2.257679	2.257918	2.258158	2.258398	2.258637	239
182	2.260071	2.260310	2.260548	2.260787	2.261025	238
183	2.262451	2.262688	2.262925	2.263162	2.263399	237
184	2.264818	2.265054	2.265290	2.265525	2.265761	235
185	2.267172	2.267406	2.267641	2.267875	2.268110	234

Num	5	6	7	8	9	Diff.
143	2.156852	2.157154	2.157457	2.157759	2.158061	303
144	2.159868	2.160168	2.160468	2.160769	2.161068	301
145	2.162863	2.163161	2.163460	2.163757	2.164055	299
146	2.165838	2.166134	2.166430	2.166726	2.167022	297
147	2.168792	2.169086	2.169380	2.169674	2.169968	295
148	2.171726	2.172019	2.172311	2.172603	2.172895	292
149	2.174641	2.174932	2.175222	2.175512	2.175802	291
150	2.177536	2.177825	2.178113	2.178401	2.178689	289
151	2.180413	2.180699	2.180986	2.181272	2.181558	287
152	2.183270	2.183554	2.183839	2.184123	2.184407	285
153	2.186108	2.186391	2.186674	2.186956	2.187239	283
154	2.188928	2.189209	2.189490	2.189771	2.190051	281
155	2.191730	2.192010	2.192289	2.192567	2.192846	279
156	2.194514	2.194792	2.195069	2.195346	2.195623	278
157	2.197281	2.197556	2.197832	2.198107	2.198382	276
158	2.200029	2.200303	2.200577	2.200850	2.201124	274
159	2.202761	2.203033	2.203305	2.203577	2.203848	272
160	2.205475	2.205745	2.206016	2.206286	2.206556	271
161	2.208172	2.208441	2.208710	2.208978	2.209247	269
162	2.210853	2.211120	2.211388	2.211654	2.211921	267
163	2.213518	2.213783	2.214049	2.214314	2.214579	266
164	2.216166	2.216430	2 216694	2.216957	2.217221	264
165	2.218798	2.219060	2.219322	2.219584	2.219846	262
166	2.221414	2.221675	2.221936	2.222196	2.222456	261
167	2.224015	2.224274	2.224533	2.224792	2.225051	259
168	2.226600	2.226858	2.227115	2.227372	2.227630	258
169	2.229170	2.229426	2.229682	2.229938	2.230193	256
170	2.231724	2.231979	2.232233	2.232488	2.232742	254
171	2.234264	2.234517	2.234770	2.235023	2.235276	253
172	2.236789	2.237041	2.237292	2.237544	2.237795	251
173	2.239299	2.239550	2.239800	2.240050	2.240300	250
174	2.241795	2.242044	2.242293	2.242541	2.242790	249
175	2.244277	2.244524	2.244772	2.245019	2.245266	248
176	2.246745	2.246991	2.247236	2.247482	2.247728	246
177	2.249198	2.249443	2.249687	2.249932	2.250176	245
178	2.251638	2.251881	2.252125	2.252367	2.252610	243
179	2.254064	2.254306	2.254548	2.254790	2.255031	242
180	2.256477	2.256718	2.256958	2.257198	2.257439	241
181	2.258877	2.259116	2.259355	2.259594	2.259833	239
182	2.261263	2.261501	2.261738	2 261976	2.262214	238
183	2.263636	2.263873	2.264109	2.264345	2.264582	237
184	2.265996	2.266232	2.266467	2.266702	2.266937	235
185	2.268344	2.268578	2.268812	2.269046	2.269279	234

Num	0	1	2	3	4	Diff.
186	2.269513	2.269746	2.269980	2.270213	2.270446	233
187	2.271842	2.272074	2.272306	2.272538	2.272770	232
188	2.274158	2.274389	2.274620	2.274850	2.275081	230
189	2.276462	2.276691	2.276921	2.277151	2.277380	229
190	2.278754	2.278982	2.279210	2.279439	2.279667	228
191	2.281033	2.281261	2.281488	2.281715	2.281942	227
192	2.283301	2.283527	2.283753	2.283979	2.284205	226
193	2.285557	2.285782	2.286007	2.286232	2.286456	225
194	2.287802	2.288025	2.288249	2 288473	2.288696	223
195	2.290035	2.290257	2.290480	2.290702	2.290925	222
196	2.292256	2.292478	2.292699	2.292920	2.293141	221
197	2.294466	2.294687	2.294907	2.295127	2 295347	220
198	2.296665	2.296884	2.297104	2.297323	2.297542	219
199	2.298853	2.299071	2.299289	2.299507	2.299725	218
200	2.301030	2.301247	2,301464	2,301681	2.301898	217
201	2.303196	2.303412	2.303628	2.303844	2.304059	216
202	2.305351	2.305566	2.305781	2.305996	2.306210	215
203	2.307496	2.307710	2.307924	2.308137	2.308351	213
204	2.309630	2.309843	2 310056	2.310268	2.310481	212
205	2.311754	2.311966	2.312177	2.312389	2.312600	211
206	2.313867	2.314078	2.314289	2.314499	2.314710	210
207	2.315970	2.316180	2.316390	2.316599	2.316809	209
208	2.318063	2.318272	2.318481	2.318689	2.318898	208
209	2.320146	2.320354	2.320562	2.320769	2.320977	207
210	2.322219	2.322426	2.322633	2.322839	2.323046	206
211	2.324282	2.324488	2.324694	2.324899	2.325105	205
212	2.326336	2.326541	2 326745	2.326950	2.327154	204
213	2.328380	2.328583	2.328787	2.328991	2.329194	203
214	2.330414	2.330617	2.330819	2.331022	2.331225	202
215	2 332438	2.332640	2.332842	2.333044	2.333246	202
216	2.334454	2.334655	2.334856	2 335056	2.335257	201
217	2 336460	2.336660	2 336860	2.337060	2.337260	200
218	2.338456	2.338656	2.338855	2.339054	2.339253	199
219	2.340444	2.340642	2.340840	2.341039	2.341237	198
220	2.342423	2.342620	2.342817	2.343014	2.343212	197
221	2.344392	2.344589	2.344785	2.344981	2.345178	196
222	2.346353	2.346549	2.346744	2.346939	2.347135	195
223	2.348305	2.348500	2.348694	2.348889	2.349083	194
224	2.350248	2.350442	2.350636	2.350829	2.351023	193
225	2.352182	2.352375	2.352568	2 352761	2.352954	193
226	2.354108	2.354301	2.354493	2.354684	2.354876	192
227	2.356026	2.356217	2.356408	2.356599	2.356790	191
228	2.357935	2.358125	2.358316	2.358506	2.358696	190

Num	5	6	7	8	9	Diff.
186	2.270679	2.270912	2.271144	2.271377	2.271609	233
187	2.273001	2.273233	2.273464	2.273696	2.273927	232
188	2.275311	2.275542	2.275772	2.276002	2.276232	230
189	2.277609	2.277838	2.278067	2 278296	2.278525	229
190	2.279895	2.280123	2.280351	2.280578	2.280806	228
191	2.282169	2.282395	2.282622	2.282849	2.283075	227
192	2.284431	2.284656	2.284882	2.285107	2.285332	226
193	2.286681	2.286905	2.287130	2.287354	2.287579	225
194	2.288920	2.289143	2.289366	2.289589	2.289812	223
195	2.291147	2.291369	2.291591	2 291813	2.292034	222
196	2.293362	2.293583	2.293804	2.294025	2.294246	221
197	2.295567	2.295787	2.296007	2.296226	2.296446	220
198	2.297760	2.297979	2.298198	2.298416	2.298635	219
199	2.299943	2.300160	2.300378	2.300595	2.300813	218
200	2.302114	2.302331	2.302547	2.302764	2.302980	217
201	2.304275	2.304490	2.304706	2 304921	2.305136	216
202	2.306425	2.306639	2.306854	2.307068	2.307282	215
203	2.308564	2.308778	2.308991	2.309204	2.309417	213
204	2.310693	2.310906	2.311118	2.311330	2.311542	212
205	2.312812	2.313023	2.313234	2.313445	2.313656	211
206	2.314920	2.315130	2.315340	2.315550	2.315760	210
207	2.317018	2.317227	2.317436	2.317645	2.317854	209
208	2.319106	2.319314	2.319522	2.319730	2.319938	208
209	2 321184	2.321391	2.321598	2.321805	2.322012	207
210	2.323252	2.323458	2.323664	2.323871	2.324077	206
211	2.325310	2.325516	2.325721	2.325926	2.326131	205
212	2.327359	2.327563	2 327767	2.327972	2.328176	204
213	2.329398	2.329601	2.329804	2.330008	2 330211	203
214	2.331427	2.331630	2.331832	2 332034	2.332236	202
215	2.333447	2.333649	2.333850	2 334051	2.334253	202
216	2.335458	2.335658	2.335859	2.336059	2.336259	201
217	2.337459	2.337659	2.337858	2.338058	2.338257	200
218	2.339451	2.339650	2.339849	2.340047	2.340246	199
219	2.341434	2.341632	2.341830	2.342028	2.342225	198
220	2.343409	2.343605	2.343802	2.343999	2.344196	197
221	2.345374	2.345570	2.345766	2.345961	2.346157	196
222	2.347330	2.347525	2.347720	2.347915	2.348110	195
223	2.349277	2.349472	2.349666	2.349860	2.350054	194
224	2.351216	2.351410	2.351603	2.351796	2.351989	193
225	2.353146	2.353339	2.353532	2.353724	2.353916	193
226	2.355068	2.355260	2.355451	2.355643	2.355834	192
227	2.356981	2.357172	2.357363	2.357554	2.357744	191
228	2.358886	2.359076	2.359266	2.359456	2.359646	190

Num	0	1	2	3	4	Diff.
229	2.359835	2.360025	2.360215	2.360404	2.360593	189
230	2.361728	2.361917	2.362105	2.362294	2.362482	188
231	2.363612	2.363800	2.363988	2.364176	2.364363	188
232	2.365488	2.365675	2.365862	2.366049	2.366236	187
233	2.367356	2.367542	2.367728	2.367915	2.368101	186
234	2.369216	2.369401	2.369587	2.369772	2.369958	185
235	2.371068	2.371253	2.371437	2.371622	2.371806	184
236	2.372912	2.373096	2.373280	2.373464	2.373647	184
237	2.374748	2.374932	2.375115	2.375298	2.375481	183
238	2.376577	2.376759	2.376942	2.377124	2.377306	182
239	2.378398	2.378580	2.378761	2.378943	2.379124	181
240	2.380211	2.380392	2.380573	2.380754	2.380934	181
241	2.382017	2.382197	2.382377	2.382557	2.382737	180
242	2.383815	2.383995	2.384174	2.384353	2.384533	179
243	2.385606	2.385785	2.385964	2.386142	2.386321	178
244	2.387390	2.387568	2.387746	2.387923	2.388101	178
245	2.389166	2.389343	2.389520	2.389697	2.389874	177
246	2.390935	2.391111	2.391288	2.391464	2.391641	176
247	2.392697	2.392873	2.393048	2.393224	2.393400	176
248	2.394452	2.394627	2.394802	2.394977	2.395152	175
249	2.396199	2.396374	2.396548	2.396722	2.396896	174
250	2.397940	2.398114	2.398287	2.398461	2.398634	173
251	2.399674	2.399847	2.400020	2.400192	2.400365	173
252	2.401400	2.401573	2.401745	2.401917	2.402089	172
253	2.403120	2.403292	2.403464	2.403635	2.403807	171
254	2.404834	2.405005	2.405175	2.405346	2.405517	171
255	2.406540	2.406710	2.406881	2.407051	2.407221	170
256	2.408240	2.408409	2.408579	2.408749	2.408918	169
257	2.409933	2.410102	2.410271	2.410440	2.410608	169
258	2.411620	2.411788	2.411956	2.412124	2.412292	168
259	2.413300	2.413467	2.413635	2.413802	2.413970	167
260	2.414973	2.415140	2.415307	2.415474	2.415641	167
261	2.416640	2.416807	2.416973	2.417139	2.417306	166
262	2.418301	2.418467	2.418633	2.418798	2.418964	165
263	2.419956	2.420121	2.420286	2.420451	2.420616	165
264	2.421604	2.421768	2.421933	2.422097	2.422261	164
265	2.423246	2.423410	2.423573	2.423737	2.423901	164
266	2.424882	2.425045	2.425208	2.425371	2.425534	163
267	2.426511	2.426674	2.426836	2.426999	2.427161	162
268	2.428135	2.428297	2.428459	2.428621	2.428782	162
269	2.429752	2.429914	2.430075	2.430236	2.430398	161
270	2.431364	2.431525	2.431685	2.431846	2.432007	161
271	2.432969	2.433129	2.433290	2.433450	2.433610	160

Num	5	6	7	8	9	Diff.
229	2.360783	2.360972	2.361161	2.361350	2.361539	189
230	2.362671	2.362859	2.363048	2.363236	2.363424	188
231	2.364551	2.364739	2.364926	2.365113	2.365301	188
232	2.366423	2.366610	2.366796	2.366983	2.367169	187
233	2.368287	2.368473	2.368659	2.368844	2.369030	186
234	2.370143	2.370328	2.370513	2.370698	2.370883	185
235	2.371991	2.372175	2.372360	2.372544	2.372728	184
236	2.373831	2.374015	2.374198	2.374382	2.374565	184
237	2.375664	2.375846	2.376029	2.376212	2.376394	183
238	2.377488	2.377670	2.377852	2.378034	2.378216	182
239	2.379305	2.379487	2.379668	2.379849	2.380030	181
240	2.381115	2.381296	2.381476	2.381656	2.381837	181
241	2.382917	2.383097	2.383277	2.383456	2.383636	180
242	2.384712	2.384891	2.385070	2.385249	2.385427	179
243	2.386499	2.386677	2.386855	2.387034	2.387212	178
244	2.388279	2.388456	2.388634	2.388811	2.388989	178
245	2.390051	2.390228	2.390405	2.390582	2.390758	177
246	2.391817	2.391993	2.392169	2.392345	2.392521	176
247	2.393575	2.393751	2.393926	2.394101	2.394276	176
248	2.395326	2.395501	2.395676	2.395850	2.396025	175
249	2.397070	2.397245	2.397418	2.397592	2.397766	174
250	2.398808	2.398981	2.399154	2.399327	2.399501	173
251	2.400538	2.400711	2.400883	2.401056	2.401228	173
252	2.402261	2.402433	2.402605	2.402777	2.402949	172
253	2.403978	2.404149	2.404320	2.404492	2.404663	171
254	2.405688	2.405858	2.406029	2.406199	2.406370	171
255	2.407391	2.407561	2.407731	2.407900	2.408070	170
256	2.409087	2.409257	2.409426	2.409595	2.409764	169
257	2.410777	2.410946	2.411114	2.411283	2.411451	169
258	2.412460	2.412628	2.412796	2.412964	2.413132	168
259	2.414137	2.414305	2.414472	2.414639	2.414806	167
260	2.415808	2.415974	2.416141	2.416308	2.416474	167
261	2.417472	2.417638	2.417804	2.417970	2.418135	166
262	2.419129	2.419295	2.419460	2.419625	2.419791	165
263	2.420781	2.420945	2.421110	2.421275	2.421439	165
264	2.422426	2.422590	2.422754	2.422918	2.423082	164
265	2.424064	2.424228	2.424392	2.424555	2.424718	163
266	2.425697	2.425860	2.426023	2.426186	2.426349	163
267	2.427324	2.427486	2.427648	2.427811	2.427973	162
268	2.428944	2.429106	2.429268	2.429429	2.429591	162
269	2.430559	2.430720	2.430881	2.431042	2.411203	161
270	2.432167	2.432328	2.432488	2.432649	2.412809	160
271	2.433770	2.433930	2.434090	2.434249	2.414409	160

Num	0	1	2	3	4	Diff.
272	2.434569	2.434728	2.434888	2.435048	2.435207	159
273	2.436163	2.436322	2.436481	2.436640	2.436798	159
274	2.437751	2.437909	2.438067	2.438226	2.438384	158
275	2.439333	2.439491	2.439648	2.439806	2.439964	158
276	2.440909	2.441066	2.441224	2.441381	2.441538	157
277	2.442480	2.442636	2.442793	2.442950	2.443106	157
278	2.444045	2.444201	2.444357	2.444513	2.444669	156
279	2.445604	2.445760	2.445915	2.446071	2.446226	155
280	2.447158	2.447313	2.447468	2 447623	2.447778	155
281	2.448706	2.448861	2.449015	2.449170	2.449324	154
282	2.450249	2.450403	2.450557	2.450711	2.450865	154
283	2.451786	2.451940	2.452093	2.452247	2 452400	153
284	2.453318	2.453471	2.453624	2.453777	2.453930	153
285	2.454845	2.454997	2.455149	2.455302	2.455454	152
286	2.456366	2.456518	2,456670	2,456821	2.456973	152
287	2.457882	2.458033	2.458184	2.458336	2.458487	151
288	2.459392	2.459543	2.459694	2.459845	2.459995	151
289	2.460898	2.461048	2 461198	2.461348	2.461498	150
290	2.462398	2.462548	2.462697	2.462847	2.462997	150
291	2.463893	2.464042	2.464191	2.464340	2.464489	149
292	2.465383	2.465532	2.465680	2.465829	2.465977	149
293	2.466868	2.467016	2.467164	2.467312	2.467460	148
294	2.468347	2.468495	2.468643	2.468790	2.468938	147
295	2.469822	2.469969	2.470116	2.470263	2.470410	147
296	2.471292	2.471438	2.471585	2.471732	2.471878	146
297	2.472756	2.472903	2.473049	2.473195	2.473341	146
298	2.474216	2.474362	2 474508	2.474653	2 474799	145
299	2.475671	2.475816	2.475962	2.476107	2.476252	145
300	2.477121	2.477266	2.477411	2.477555	2.477700	145
301	2.478566	2.478711	2.478855	2.478999	2.479143	144
302	2.480007	2.480151	2.480294	2.480438	2.480582	144
303	2 481443	2.481586	2 481729	2.481872	2.482016	143
304	2.482874	2.483016	2.483159	2.483302	2.483449	143
305	2.484300	2 484442	2.484584	2.484727	2.484869	142
306	2.485721	2.485863	2.486005	2.486147	2.486289	142
307	2 487138	2.487280	2.487421	2 487563	2.487704	141
308	2.488551	2.488692	2 488833	2.488973	2.489114	141
309	2.489958	2.490099	2.490239	2.490380	2.490520	140
310	2.491362	2.491502	2.491642	2.491782	2.491922	140
311	2.492760	2.492900	2.493040	2 493179	2.493319	139
312	2.494155	2.494294	2.494433	2.494572	2.494711	139
313	2.495544	2.495683	2.495822	2.495960	2 496099	139
314	2.496930	2.497068	2.497206	2.497344	2.497482	138

Num	5	6	7	8	9	Diff.
272	2.435366	2.435526	2.435685	2.435844	2.436003	159
273	2.436957	2.437116	2.437275	2.437433	2.437592	159
274	2.438542	2.438700	2.438859	2.439017	2.439175	158
275	2.440122	2.440279	2.440437	2.440594	2.440752	158
276	2.441695	2.441852	2.442009	2.442166	2.442323	157
277	2.443263	2 443419	2.443576	2.443732	2.443888	157
278	2.444825	2.444981	2.445137	2.445293	2.445448	156
279	2.446382	2.446537	2.446692	2.446848	2.447003	155
280	2 447933	2.448088	2.448242	2.448397	2.448552	155
281	2.449478	2.449633	2.449787	2.449941	2.450095	154
282	2.451018	2.451172	2.451326	2.451479	2.451633	154
283	2.452553	2.452706	2.452859	2.453012	2.453165	153
284	2.454082	2.454235	2.454387	2.454540	2.454692	153
285	2.455606	2.455758	2.455910	2.456062	2.456214	152
286	2.457125	2.457276	2 457428	2.857579	2.457730	152
287	2.458638	2.458789	2.458940	2.459091	2.459242	151
288	2.460146	2.460296	2.460447	2.460597	2.460747	151
289	2.461649	2.461799	2.461948	2.462098	2.462248	150
290	2.463146	2.463296	2.463445	2.463594	2.463744	150
291	2.464639	2.464787	2.464936	2.465085	2.465234	149
292	2.466126	2.466274	2.466423	2.466571	2.466719	149
293	2.467608	2.467756	2 467904	2.468052	2.468200	148
294	2.469085	2.469233	2.469380	2.469527	2 469675	147
295	2.470557	2.470704	2.470851	2.470998	2.471145	147
296	2.472025	2.472171	2.472317	2 472464	2.472610	146
297	2.473487	2.473633	2.473779	2.473925	2.474070	146
298	2.474944	2.475090	2.475235	2.475381	2.475526	146
299	2.476397	2.476542	2.476687	2 476832	2.476976	145
300	2.477844	2.477989	2.478133	2.478278	2.478422	145
301	2.479287	2.479431	2.479575	2.479719	2 479863	144
302	2.480725	2.480869	2.481012	2.481156	2.481299	144
303	2.482159	2.482302	2.482445	2.482588	2.482731	143
304	2.483587	2.483730	2.483872	2.484015	2 484157	143
305	2.485011	2.485153	2.485295	2.485437	2.485579	142
306	2.486430	2.486572	2.486714	2 486855	2.486997	142
307	2.487845	2.487986	2.488127	2.488269	2.488410	141
308	2.489255	2.489396	2.489537	2.489677	2.489818	141
309	2.490661	2.490801	2.490941	2.491081	2.491222	140
310	2.492062	2.492201	2.492341	2.492481	2.492621	140
311	2.493458	2.493597	2.493737	2.493876	2.494015	139
312	2.494850	2.494989	2.495128	2 495267	2.495406	139
313	2.496237	2.496376	2.496514	2.496653	2.496791	139
314	2.497621	2.497759	2.497897	2.498035	2.498173	138

Num	0	1	2	3	4	Diff.
315	2.498311	2.498448	2.498586	2.498724	2.498862	138
316	2.499687	2.499824	2.499962	2.500100	2.500236	137
317	2.501059	2.501196	2.501333	2.501470	2.501607	137
318	2.502427	2.502564	2.502700	2.502837	2.502973	136
319	2.503791	2.503927	2.504063	2.504199	2.504335	136
320	2.505150	2.505286	2.505421	2.505557	2.505693	136
321	2.506505	2.506640	2.506775	2.506911	2.507046	135
322	2.507856	2.507991	2.508125	2.508260	2.508395	135
323	2.509202	2.509337	2.509471	2 509606	2.509740	134
324	2.510545	2.510679	2.510813	2.510947	2.511081	134
325	2.511883	2.512017	2.512150	2.512284	2.512417	133
326	2.513218	2.513351	2.513484	2.513617	2 513750	133
327	2.514548	2.514680	2.514813	2.514946	2.515079	133
328	2.515874	2.516006	2.516139	2.516271	2.516403	132
329	2.517196	2.517328	2,517460	2,517592	2.517724	132
330	2.518514	2.518645	2.518777	2.518909	2.519040	132
231	2.519828	2.519959	2.520090	2.520221	2.520352	131
332	2.521138	2.521269	2 521400	2.521530	2.521661	131
333	2.522444	2.522575	2.522705	2.522835	2.522966	130
334	2.523746	2.523876	2.524006	2.524136	2.524266	130
335	2.525045	2.525174	2.525304	2.525433	2.525563	130
336	2.526339	2.526468	2.526598	2.526727	2.526856	129
337	2.527630	2.527759	2.527888	2.528016	2.528145	129
338	2.528917	2.529045	2.529174	2.529302	2.529430	128
339	2.530200	2.530328	2.530456	2.530584	2.530712	128
340	2.531479	2.531607	2 531734	2.531862	2.531989	128
341	2.532754	2.532882	2.533009	2.533136	2.533263	127
342	2.534026	2 534153	2.534280	2.534407	2.534534	127
343	2.535294	2.535421	2.535547	2.535674	2.535800	126
344	2 536558	2.536685	2.536811	2.536937	2.537063	126
345	2.537819	2.537945	2.538071	2 538197	2.538322	126
346	2.539076	2.539202	2 539327	2.539452	2.539578	125
347	2.540329	2.540455	2.540580	2.540705	2.540830	125
348	2.541579	2 541704	2.541829	2.541953	2.542078	125
349	2.542825	2.542950	2.543074	2.543199	2.543323	124
350	2.544068	2.544192	2.544316	2 544440	2.544564	124
351	2.545307	2.545431	2.545554	2.545678	2 545802	124
352	2.546543	2.546666	2.546789	2.546913	2.547036	123
353	2.547775	2.547898	2.548021	2.548144	2.548266	123
354	2.549003	2.549126	2.549249	2 549371	2.549494	123
355	2.550228	2.550351	2.550473	2.550595	2.550717	122
356	2.551450	2.551572	2.551694	2.551816	2 551938	122
357	2.552668	2.552790	2.552911	2.553033	2 553154	121

Num	5	6	7	8	9	Diff
315	2.498999	2.499137	2.499275	2.499412	2.499550	138
316	2.500374	2.500511	2.500648	2.500785	2.500922	137
317	2.501744	2.501880	2.502017	2.502154	2.502290	137
318	2.503109	2.503246	2.503382	2.503518	2.503654	136
319	2.504471	2.504607	2.504743	2.504878	2.505014	136
320	2.505828	2.505963	2.506099	2.506234	2.506370	136
321	2.507181	2.507316	2.507451	2.507586	2.507721	135
322	2.508530	2.508664	2.508799	2.508933	2.509068	135
323	2.509874	2.510008	2.510143	2.510277	2.510411	134
324	2.511215	2.511348	2.511482	2.511616	2.511750	134
325	2.512551	2.512684	2.512818	2.512951	2.513084	133
326	2.513883	2.514016	2.514149	2.514282	2.514415	133
327	2.515211	2.515344	2.515476	2.515609	2.515741	133
328	2.516535	2.516668	2.516800	2.516932	2.517064	132
329	2.517855	2.517987	2.518119	2.518251	2.518382	132
330	2.519171	2.519303	2.519434	2.519565	2.519697	132
331	2.520483	2.520614	2.520745	2.520876	2.521007	131
332	2.521792	2.521922	2.522053	2.522183	2.522314	131
333	2.523096	2.523226	2.523356	2.523486	2.523616	130
334	2.524396	2.524526	2.524656	2.524785	2.524915	130
335	2.525692	2.525822	2.525951	2.526081	2.526210	129
336	2.526985	2.527114	2.527243	2.527372	2.527501	129
337	2.528274	2.528402	2.528531	2.528660	2.528788	129
338	2.529559	2.529687	2.529815	2.529943	2.530072	128
339	2.530840	2.530968	2.531095	2.531223	2.531351	128
340	2.532117	2.532245	2.532372	2.532500	2.532627	128
341	2.533391	2.533518	2.533645	2.533772	2.533899	127
342	2.534661	2.534787	2.534914	2.535041	2.535167	127
343	2.535927	2.536053	2.536179	2.536306	2.536432	126
344	2.537189	2.537315	2.537441	2.537567	2.537693	126
345	2.538448	2.538574	2.538699	2.538825	2.538951	126
346	2.539703	2.539829	2.539954	2.540079	2.540204	125
347	2.540955	2.541080	2.541205	2.541330	2.541454	125
348	2.542203	2.542327	2.542452	2.542576	2.542701	125
349	2.543447	2.543571	2.543696	2.543820	2.543944	124
350	2.544688	2.544812	2.544936	2.545060	2.545183	124
351	2.545925	2.546049	2.546172	2.546296	2.546419	124
352	2.547159	2.547282	2.547405	2.547529	2.547652	123
353	2.548389	2.548512	2.548635	2.548758	2.548881	123
354	2.549616	2.549739	2.549861	2.549984	2.550106	123
355	2.550840	2.550962	2.551084	2.551206	2.551328	122
356	2.552059	2.552181	2.552303	2.552425	2.552546	122
357	2.553276	2.553397	2.553519	2.553640	2.553762	121

Num	0	1	2	3	4	Diff.
358	2.553883	2.554004	2.554126	2.554247	2.554368	121
359	2.555094	2.555215	2.555336	2.555457	2.555578	121
360	2.556302	2.556423	2.556544	2.556664	2.556785	121
361	2.557507	2.557627	2.557748	2.557868	2.557988	120
362	2.558709	2.558828	2.558948	2.559068	2.559188	120
363	2.559907	2.560026	2.560146	2.560265	2.560385	120
364	2 61101	2.561221	2.561340	2.561459	2.561578	119
365	2.562293	2.562412	2.562531	2.562650	2.562768	119
366	2.563481	2.563600	2.563718	2.563837	2.563955	119
367	2,564666	2.564784	2.564903	2.565021	2.565139	118
368	2.565848	2.565966	2.566084	2.566202	2.566320	118
369	2.567026	2.567144	2.567262	2.567379	2.567497	118
370	2.568202	2.568319	2.568436	2.568554	2.568671	117
371	2.569374	2.569491	2.569608	2.569725	2.569842	117
372	2.570543	2.570660	2.570776	2.570893	2.571010	117
373	2.571709	2.571825	2 571942	2.572058	2.572174	116
374	2.572872	2.572988	2.573104	2.573220	2.573336	116
375	2.574031	2.574147	2.574263	2.574379	2 574494	116
376	2.575188	2.575303	2.575419	2.575534	2.575650	115
377	2.576341	2.576456	2.576572	2.576687	2.576802	115
378	2.577492	2.577607	2.577721	2.577836	2.577951	115
379	2.578639	2.578754	2.578868	2.578983	2.579097	114
380	2.579784	2.579898	2.580012	2.580126	2.580240	114
381	2.580925	2.581039	2.581153	2.581267	2.581381	114
382	2.582063	2.582177	2.582291	2.582404	2.582518	114
383	2 583199	2.583312	2.583425	2.583539	2.583652	113
384	2.584331	2.584444	2.584557	2.584670	2.584783	113
385	2 85461	2.585573	2.585686	2.585799	2.585912	113
386	2 586587	2.586700	2.586812	2.586925	2.587037	112
387	2.587711	2.587823	2.587935	2.588047	2.588160	112
388	2.588832	2.588944	2.589055	2.589167	2.589279	112
389	2.589950	2.590061	2.590173	2.590284	2.590396	112
390	2.591065	2.591176	2.591287	2.591398	2.591510	111
391	2.592177	2.592288	2.592399	2.592510	2.592621	111
392	2.593286	2.593397	2.593508	2.593618	2.593729	111
393	2.594392	2.594503	2.594613	2.594724	2.594834	110
394	2.595496	2.595606	2.595717	2.595827	2.595937	110
395	2.596597	2.596707	2.596817	2.596927	2.597037	110
396	2.597695	2.597805	2.597914	2.598024	2.598134	110
397	2.598790	2.598900	2.599009	2.599119	2.599228	109
398	2.599883	2.599992	2.600101	2.600210	2.600319	109
399	2.600973	2.601082	2.601190	2.601299	2.601408	109
400	2.602060	2 602168	2.602277	2.602386	2.602494	108

Num	5	6	7	8	9	Diff.
358	2.554489	2.554610	2.554731	2.554852	2.554973	121
359	2.555699	2.555820	2.555940	2.556061	2.556182	121
360	2.556905	2.557026	2.557146	2.557266	2.557387	121
361	2.558108	2.558228	2.558348	2.558469	2.558589	120
362	2.559308	2.559428	2.559548	2.559667	2.559787	120
363	2.560504	2.560624	2.560743	2.560863	2.560982	119
364	2.561697	2.561817	2.561936	2.562055	2.562174	119
365	2.562887	2.563006	2.563125	2.563244	2.563362	119
366	2.564074	2.564192	2.564311	2.564429	2.564548	119
367	2.565257	2.565375	2.565494	2.565612	2.565730	118
368	2.566437	2.566555	2.566673	2.566791	2.566909	118
369	2.567614	2.567732	2.567849	2.567967	2.568084	118
370	2.568788	2.568905	2.569023	2.569140	2.569257	117
371	2.569959	2.570076	2.570193	2.570309	2.570426	117
372	2.571126	2.571243	2.571359	2.571476	2.571592	117
373	2.572291	2.572407	2.572523	2.572639	2.572755	116
374	2.573452	2.573568	2.573684	2.573800	2.573915	116
375	2.574610	2.574726	2.574841	2 574957	2.575072	116
376	2.575765	2.575880	2.575996	2.576111	2.576226	115
377	2.576917	2.577032	2.577147	2.577262	2.577377	115
378	2.578066	2.578181	2.578295	2.578410	2.578525	115
379	2.579212	2.579326	2.579441	2.579555	2.579669	114
380	2.580355	2.580469	2.580583	2.580697	2.580811	114
381	2.581495	2.581608	2.581722	2.581836	2.581950	114
382	2.582631	2.582745	2.582858	2.582972	2.583085	114
383	2.583765	2.583879	2.583992	2.584105	2.584218	113
384	2.584896	2.585009	2.585122	2.585235	2.585348	113
385	2.586024	2.586137	2.586250	2.586362	2.586475	113
386	2.587149	2.587262	2.587374	2.587486	2.587599	112
387	2.588272	2.588384	2.588496	2.588608	2.588720	112
388	2.589391	2.589503	2.589614	2.589726	2.589838	112
389	2.590507	2.590619	2.590730	2.590842	2.590953	112
390	2.591621	2.591732	2.591843	2.591955	2.592066	111
391	2.592732	2.592843	2.592954	2.593064	2.593175	111
392	2.593840	2.593950	2.594061	2.594171	2.594282	111
393	2.594945	2.595055	2.595165	2.595276	2.595386	110
394	2.596047	2.596157	2.596267	2.596377	2.596487	110
395	2.597146	2.597256	2.597366	2.597476	2.567585	110
396	2.598243	2.598353	2.598462	2.598572	2.598681	110
397	2.599337	2.599446	2.599556	2.599665	2.599774	109
398	2.600428	2.600537	2.600646	2.600755	2.600864	109
399	2.601517	2.601625	2.601734	2.601843	2.601951	109
400	2.602602	2.602711	2.602819	2.602928	2 603036	108

Num	0	1	2	3	4	Dift.
401	2.603144	2.603253	2.603361	2.603469	2.603577	108
402	2.604226	2.604334	2.604442	2.604550	2.604658	108
403	2.605305	2.605413	2.605520	2.605628	2.605736	108
404	2.606381	2 606489	2.606596	2.606704	2.606811	107
405	2.607455	2.607562	2.607669	2.607777	2.607884	107
406	2.608526	2.608633	2.608740	2.608847	2.608954	107
407	2.609594	2.609701	2.609808	2.609914	2.610021	107
408	2.610660	2.610767	2.610873	2.610979	2.611086	106
409	2.611723	2.611829	2.611936	2.612042	2.612148	106
410	2.612784	2.612890	2.612996	2.613102	2.613208	106
411	2.613842	2.613947	2.614053	2.614159	2.614264	106
412	2.614897	2.615003	2.615108	2.615213	2.615319	105
413	2.615950	2.616055	2.616160	2.616265	2.616370	105
414	2.617000	2.617105	2.617210	2.617315	2.617420	105
415	2.618048	2.618153	2.618257	2.618362	2.618466	105
416	2.619093	2.619198	2.619302	2.619406	2.619511	104
417	2.620136	2.620240	2.620344	2.620448	2.620552	104
418	2.621176	2.621280	2.621384	2.621488	2.621592	104
419	2.622214	2.622318	2.622421	2.622525	2.622628	104
420	2.623249	2.623353	2.623456	2.623559	2 623663	103
421	2.624282	2.624385	2.624488	2.624591	2.624694	103
422	2.625312	2.625415	2.625518	2.625621	2.625724	103
423	2.626340	2.626443	2.626546	2.626648	2.626751	103
424	2.627366	2.627468	2.627571	2.627673	2.627775	102
425	2.628389	2.628491	2.628593	2.628695	2.628797	102
426	2.629410	2.629511	2.629613	2.629715	2.629817	102
427	2.630428	2.630529	2.630631	2.630733	2.630834	102
428	2.631444	2.631545	2.631647	2.631748	2.631849	101
429	2.632457	2.632558	2.632660	2.632761	2.632862	101
430	2.633468	2.633569	2.633670	2.633771	2.633872	101
431	2.634477	2.634578	2.634679	2.634779	2.634880	100
432	2.635484	2.635584	2.635685	2.635785	2.635886	100
433	2.636488	2.636588	2.636688	2.636789	2.636889	100
434	2.637490	2.637590	2.637690	2.637790	2.637890	100
435	2.638489	2.638589	2.638689	2.638789	2.638888	99
436	2.639486	2.639586	2.639686	2.639785	2.639885	99
437	2.640481	2.640581	2.640680	2.640779	2.640879	99
438	2.641474	2.641573	2.641672	2.641771	2.641870	99
439	2.642464	2.642563	2.642662	2.642761	2.642860	99
440	2.643453	2.643551	2.643650	2.643749	2.643847	98
441	2.644439	2.644537	2.644635	2.644734	2.644832	98
442	2.645422	2.645520	2.645619	2.645717	2.645815	98
443	2.646404	2.646502	2.646600	2.646698	2.646796	98

Num	5	6	7	8	9	Diff.
401	2.603685	2.603794	2.603902	2.604010	2.604118	108
402	2.604766	2.604874	2.604982	2.605089	2.605197	108
403	2.605843	2.605951	2.606059	2.606166	2.606274	108
404	2.606918	2.607026	2.607133	2.607240	2.607348	107
405	2.607991	2.608098	2.608205	2.608312	2.608419	107
406	2.609060	2.609167	2.609274	2.609381	2.609488	107
407	2.610128	2.610244	2.610341	2.610447	2.610554	107
408	2.611192	2.611298	2.611405	2.611511	2.611617	106
409	2.612254	2.612360	2.612466	2.612572	2.612678	106
410	2.613313	2.613419	2.613525	2.613630	2.613736	106
411	2.614370	2.614475	2.614581	2.614086	2.614792	106
412	2.615424	2.615529	2.615634	2.615740	2.615845	105
413	2.616475	2.616580	2.616685	2.616790	2.616895	105
414	2.617524	2.617629	2.617734	2.617839	2.617943	105
415	2.618571	2.618675	2.618780	2.618884	2.618989	105
416	2.619615	2.619719	2.619823	2.619928	2.620032	104
417	2.620656	2.620760	2.620864	2.620968	2.621072	104
418	2.621695	2.621799	2.621903	2.622007	2.622110	104
419	2.622732	2.622835	2.622939	2.623042	2.623146	104
420	2.623766	2.623869	2.623972	2.624076	2.624179	103
421	2.624798	2.624901	2.625004	2.625107	2.625209	103
422	2.625827	2.625929	2.626032	2.626135	2.626238	103
423	2.626853	2.626956	2.627058	2.627161	2.627263	103
424	2.627878	2.627980	2.628082	2.628184	2.628287	102
425	2.628900	2.629002	2.629104	2.629206	2.629308	102
426	2.629919	2.630021	2.630123	2.630224	2.630326	102
427	2.630936	2.631038	2.631139	2.631241	2.631342	102
428	2.631951	2.632052	2.632153	2.632255	2.632356	101
429	2.632963	2.633064	2.633165	2.633266	2.633367	101
430	2.633973	2.634074	2.634175	2.634276	2.634376	100
431	2.634981	2.635081	2.635182	2.635283	2.635383	100
432	2.635986	2.636086	2.636187	2.636287	2.636388	100
433	2.636989	2.637089	2.637189	2.637289	2.637390	100
434	2.637990	2.638090	2.638190	2.638289	2.638389	99
435	2.638988	2.639088	2.639188	2.639287	2.639387	99
436	2.639984	2.640084	2.640183	2.640283	2.640382	99
437	2.640978	2.641077	2.641176	2.641276	2.641375	99
438	2.641970	2.642069	2.642168	2.642267	2.642366	99
439	2.642959	2.643058	2.643156	2.643255	2.643354	99
440	2.643946	2.644044	2.644143	2.644242	2.644340	98
441	2.644931	2.645029	2.645127	2.645226	2.645324	98
442	2.645913	2.646011	2.646109	2.646208	2.646306	98
443	2.646894	2.646991	2.647089	2.647187	2.647285	98

Num	0	1	2	3	4	Diff.
444	2.647383	2.647481	2.647578	2.647676	2.647774	98
445	2.648360	2.648458	2.648555	2.648653	2.648750	97
446	2.649335	2.649432	2.649530	2.649627	2.649724	97
447	2.650307	2.650405	2.650502	2.650599	2.650696	97
448	2.651278	2.651375	2.651472	2.651569	2.651666	97
449	2.652246	2.652343	2.652440	2.652536	2.652633	97
450	2.653212	2.653309	2.653405	2.653502	2.653598	96
451	2.654176	2.654273	2.654369	2.654465	2.654562	96
452	2.655138	2.655234	2.655331	2.655427	2.655523	96
453	2.656098	2.656194	2.656290	2.656386	2.656481	96
454	2.657056	2.657151	2.657247	2.657343	2.657438	96
455	2.658011	2.658107	2.658202	2.658298	2.658393	95
456	2.658965	2.659060	2.659155	2.659250	2.659346	95
457	2.659916	2.660011	2.660106	2.660201	2.660296	95
458	2.660865	2.660960	2.661055	2.661150	2.661245	95
459	2.661813	2.661907	2.662002	2.662096	2.662191	95
460	2.662758	2.662852	2.662947	2.663041	2.663135	94
461	2.663701	2.663795	2.663889	2.663983	2.664078	94
462	2.664642	2.664736	2.664830	2.664924	2.665018	94
463	2.665581	2.665675	2.665768	2.665862	2.665956	94
464	2.666518	2.666612	2.666705	2.666799	2.666892	94
465	2.667453	2.667546	2.667640	2.667733	2.667826	93
466	2.668386	2.668479	2.668572	2.668665	2.668758	93
467	2.669317	2.669410	2.669503	2.669596	2.669689	93
468	2.670246	2.670339	2.670431	2.670524	2.670617	93
469	2.671173	2.671265	2.671358	2.671451	2.671543	93
470	2.672098	2.672190	2.672283	2.672375	2.672467	92
471	2.673021	2.673113	2.673205	2.673297	2.673390	92
472	2.673942	2.674034	2.674126	2.674218	2.674310	92
473	2.674861	2.674953	2.675045	2.675136	2.675228	92
474	2.675778	2.675870	2.675961	2.676053	2.676145	92
475	2.676694	2.676785	2.676876	2.676968	2.677059	91
476	2.677607	2.677698	2.677789	2.677881	2.677972	91
477	2.678518	2.678609	2.678700	2.678791	2.678882	91
478	2.679428	2.679519	2.679610	2.679700	2.679791	91
479	2.680335	2.680426	2.680517	2.680607	2.680698	91
480	2.681241	2.681332	2.681422	2.681513	2.681603	90
481	2.682145	2.682235	2.682326	2.682416	2.682506	90
482	2.683047	2.683137	2.683227	2.683317	2.683407	90
483	2.683947	2.684037	2.684127	2.684217	2.684307	90
484	2.684845	2.684935	2.685025	2.685114	2.685204	90
485	2.685742	2.685831	2.685921	2.686010	2.686100	89
486	2.686636	2.686726	2.686815	2.686904	2.686994	89

Num	5	6	7	8	9	Diff.
444	2.647872	2.647969	2.648067	2.648165	2.648262	98
445	2.648848	2.648945	2.649043	2.649140	2.649237	97
446	2.649821	2.649919	2.650016	2.650113	2.650210	97
447	2.650793	2.650890	2.650987	2.651084	2.651181	97
448	2.651762	2.651859	2.651956	2.652053	2.652150	97
449	2.652730	2.652826	2.652923	2.653019	2.653116	97
450	2.653695	2.653791	2.653888	2.653984	2.654080	96
451	2.654658	2.654754	2.654850	2.654946	2.655042	96
452	2.655619	2.655714	2.655810	2.655906	2.656002	96
453	2.656577	2.656673	2.656769	2.656864	2.656960	96
454	2.657534	2.657629	2.657725	2.657820	2.657916	96
455	2.658488	2.658584	2.658679	2.658774	2.658870	95
456	2.659441	2.659536	2.659631	2.659726	2.659821	95
457	2.660391	2.660486	2.660581	2.660676	2.660771	95
458	2.661339	2.661434	2.661529	2.661623	2.661718	95
459	2.662285	2.662380	2.662474	2.662569	2.662663	95
460	2.663230	2.663324	2.663418	2.663512	2.663607	94
461	2.664172	2.664266	2.664360	2.664454	2.664548	94
462	2.665112	2.665206	2.665299	2.665393	2.665487	94
463	2.666050	2.666143	2.666237	2.666331	2.666424	94
464	2.666986	2.667079	2.667173	2.667266	2.667359	94
465	2.667920	2.668013	2.668106	2.668199	2.668293	93
466	2.668852	2.668945	2.669038	2.669131	2.669224	93
467	2.669782	2.669874	2.669967	2.670060	2.670153	93
468	2.670710	2.670802	2.670895	2.670988	2.671080	93
469	2.671636	2.671728	2.671821	2.671913	2.672005	93
470	2.672560	2.672652	2.672744	2.672836	2.672929	92
471	2.673482	2.673574	2.673666	2.673758	2.673850	92
472	2.674402	2.674494	2.674586	2.674677	2.674769	92
473	2.675320	2.675412	2.675503	2.675595	2.675687	92
474	2.676236	2.676328	2.676419	2.676511	2.676602	92
475	2.677150	2.677242	2.677333	2.677424	2.677516	91
476	2.678063	2.678154	2.678245	2.678336	2.678427	91
477	2.678973	2.679064	2.679155	2.679246	2.679337	91
478	2.679882	2.679973	2.680063	2.680154	2.680245	91
479	2.680789	2.680879	2.680970	2.681060	2.681151	91
480	2.681693	2.681784	2.681874	2.681964	2.682055	90
481	2.682596	2.682686	2.682777	2.682867	2.682957	90
482	2.683497	2.683587	2.683677	2.683767	2.683857	90
483	2.684396	2.684486	2.684576	2.684666	2.684756	90
484	2.685294	2.685383	2.685473	2.685563	2.685653	90
485	2.686189	2.686279	2.686368	2.686457	2.686547	89
486	2.687083	2.687172	2.687261	2.687351	2.687440	89

Num	0	1	2	3	4	Diff.
487	2.687529	2.687618	2.687707	2.687796	2.687885	89
488	2.688420	2.688509	2.688598	2.688687	2.688776	89
489	2.689309	2.689398	2.689486	2.689575	2.689664	89
490	2.690196	2.690285	2.690373	2.690462	2.690550	89
491	2.691081	2.691170	2.691258	2.691347	2.691435	88
492	2.691965	2.692053	2.692142	2.692230	2.692318	88
493	2.692847	2.692935	2.693023	2.693111	2.693199	88
494	2.693727	2.693815	2.693903	2.693991	2.694078	88
495	2.694605	2.694693	2.694781	2.694868	2.694956	88
496	2,695482	2,695569	2.695657	2.695744	2.695832	77
497	2.696356	2.696444	2.696531	2.696618	2.696706	87
498	2.697229	2.697316	2.697404	2.697491	2.697578	87
499	2.698100	2.698188	2.698275	2.698362	2.698448	87
500	2.698970	2.699057	2.699144	2.699230	2.699317	87
501	2.699838	2.699924	2.700011	2.700098	2.700184	87
502	2.700704	2.700790	2.700877	2.700963	2.701050	86
503	2.701568	2.701654	2.701741	2.701827	2.701913	86
504	2.702430	2.702517	2.702603	2.702689	2 702775	86
505	2.703291	2.703377	2.703463	2.703549	2.703635	86
506	2.704150	2 704236	2.704322	2.704408	2.704494	86
507	2.705008	2.705094	2 705179	2.705265	2.705350	86
508	2.705864	2.705949	2.706035	2.706120	2.706205	85
509	2.706718	2.706803	2.706888	2.706974	2.707059	85
510	2.707570	2.707655	2.707740	2.707826	2.707911	85
511	2.708421	2.708506	2.708591	2.708676	2.708761	85
512	2.709270	2.709355	2.709440	2.709524	2.709609	85
513	2.710117	2.710202	2.710287	2.710371	2.710456	85
514	2 710963	2.711048	2.711132	2.711216	2.711301	84
515	2.711807	2.711891	2.711976	2.712060	2.712144	84
516	2.712650	2.712734	2.712818	2.712902	2.712986	84
517	2.713490	2.713574	2.713658	2.713742	2.713826	84
518	2.714330	2.714414	2.714497	2.714581	2.714665	84
519	2.715167	2.715251	2.715335	2.715418	2.715502	84
520	2.716003	2.716087	2.716170	2.716254	2.716337	83
521	2.716838	2.716921	2.717004	2.717088	2.717171	83
522	2.717670	2.717754	2.717837	2.717920	2.718003	83
523	2.718502	2.718585	2.718668	2.718751	2.718834	83
524	2.719331	2.719414	2.719497	2.719580	2.219663	83
525	2.720159	2.720242	2.720325	2.720407	2.720490	83
526	2.720986	2.721068	2.721151	2.721233	2.721316	82
527	2.721811	2.721893	2.721975	2.722058	2.722140	82
528	2.722634	2.722716	2.722798	2.722881	2.722963	82
529	2.723456	2.723538	2.723620	2.723702	2.723784	82

Num	5	6	7	8	9	Diff.
487	2.687975	2.688064	2.688153	2.688242	2.688331	89
488	2.688865	2.688953	2.689042	2.689131	2.689220	89
489	2.689753	2.689841	2.689930	2.690019	2.690107	89
490	2.690639	2.690727	2.690816	2.690905	2.690993	89
491	2.691523	2.691612	2.691700	2.691788	2.691877	88
492	2.692406	2.692494	2.692583	2.692671	2.692759	88
493	2.693287	2.693375	2.693463	2.693551	2.693639	88
494	2.694166	2.694254	2.694342	2.694430	2.694517	88
495	2.695044	2.695131	2.695219	2.695306	2.695394	88
496	2.695919	2.696007	2.696094	2.696182	2.696269	87
497	2.696793	2.696880	2.696968	2.697055	2.697142	87
498	2.697665	2.697752	2.697839	2.697926	2.698013	87
499	2.698535	2.698622	2.698709	2.698796	2.698883	87
500	2.699404	2.699491	2.699578	2.699664	2.699751	87
501	2.700271	2.700357	2.700444	2.700531	2.700617	87
502	2.701136	2.701222	2.701309	2.701395	2.701482	86
503	2.701999	2.702086	2.702172	2.702258	2.702344	86
504	2.702861	2.702947	2.703033	2.703119	2.703205	86
505	2.703721	2.703807	2.703893	2.703979	2.704065	86
506	2.704579	2.704665	2.704751	2.704837	2.704922	86
507	2.705436	2.705522	2.705607	2.705693	2.705778	86
508	2.706291	2.706376	2.706462	2.706547	2.706632	85
509	2.707144	2.707229	2.707315	2.707400	2.707485	85
510	2.707996	2.708081	2.708166	2.708251	2.708336	85
511	2.708846	2.708931	2.709015	2.709100	2.709185	85
512	2.709694	2.709779	2.709863	2.709948	2.710033	85
513	2.710540	2.710625	2.710710	2.710794	2.710879	85
514	2.711385	2.711470	2.711554	2.711638	2.711723	84
515	2.712229	2.712313	2.712397	2.712481	2.712565	84
516	2.713070	2.713154	2.713238	2.713322	2.713406	84
517	2.713910	2.713994	2.714078	2.714162	2.714246	84
518	2.714749	2.714832	2.714916	2.715000	2.715084	84
519	2.715586	2.715669	2.715753	2.715836	2.715920	84
520	2.716421	2.716504	2.716588	2.716671	2.716754	83
521	2.717254	2.717338	2.717421	2.717504	2.717587	83
522	2.718086	2.718169	2.718253	2.718336	2.718419	83
523	2.718917	2.719000	2.719083	2.719165	2.719248	83
524	2.719745	2.719828	2.719911	2.719994	2.720077	83
525	2.720573	2.720655	2.720738	2.720821	2.720903	83
526	2.721398	2.721481	2.721563	2.721646	2.721728	82
527	2.722222	2.722305	2.722387	2.722469	2.722552	82
528	2.723045	2.723127	2.723209	2.723291	2.723374	82
529	2.723866	2.723948	2.724030	2.724112	2.724194	82

Num	0	1	2	3	4	Diff.
530	2.724276	2.724358	2.724440	2.724522	2.724603	82
531	2.725094	2.725176	2.725258	2.725340	2.725421	82
532	2.725912	2.725993	2.726075	2.726156	2.726238	82
533	2.726727	2 726809	2.726890	2.726972	2.727053	81
534	2.727541	2.727623	2.727704	2.727785	2.727866	81
535	2.728354	2.728435	2.728516	2.728597	2.728678	81
536	2.729165	2.729246	2.729327	2.729408	2.729489	81
537	2.729974	2.730055	2.730136	2.730217	2.730298	81
538	2.730782	2.730863	2.730944	2.731024	2.731105	81
539	2.731589	2.731669	2.731750	2.731830	2.731911	81
540	2.732394	2.732474	2.732555	2.732635	2.732715	80
541	2.733197	2.733277	2.733358	2.733438	2.733518	80
542	2.733999	2.734079	2.734159	2.734240	2.734320	80
543	2.734800	2.734880	2.734960	2.735040	2.735120	80
544	2.735599	2.735679	2.735758	2.735838	2.735918	80
545	2.736396	2.736476	2.736556	2.736635	2.736715	80
546	2.737193	2.737272	2.737352	2.737431	2.737511	79
547	2.737987	2.738067	2.738146	2.738225	2.738305	79
548	2.738781	2.738860	2.738939	2.739018	2.739097	79
549	2.739572	2.739651	2.739730	2.739810	2.739889	79
550	2.740363	2.740442	2.740521	2.740599	2.740678	79
551	2.741152	2.741230	2.741309	2.741388	2.741467	79
552	2.741939	2.742018	2.742096	2.742175	2.742254	79
553	2.742725	2.742804	2.742882	2.742961	2.743039	78
554	2.743510	2.743588	2.743666	2.743745	2.743823	78
555	2.744293	2.744371	2.744449	2.744528	2.744606	78
556	2.745075	2.745153	2.745231	2.745309	2.745387	78
557	2.745855	2.745933	2.746011	2.746089	2.746167	78
558	2.746634	2.746712	2.746790	2.746868	2.746945	78
559	2.747412	2.747489	2.747567	2.747645	2.747722	78
560	2.748188	2.748266	2.748343	2.748421	2.748498	77
561	2.748963	2.749040	2.749118	2.749195	2.749272	77
562	2.749736	2.749814	2.749891	2.749968	2.750045	77
563	2.750508	2.750586	2.750663	2.750740	2.750817	77
564	2.751279	2.751356	2.751433	2.751510	2.751587	77
565	2.752048	2.752125	2.752202	2.752279	2.752356	77
566	2.752816	2.752893	2.752970	2.753047	2.753123	77
567	2.753583	2.753660	2.753736	2.753813	2.753889	77
568	2.754348	2.754425	2.754501	2.754578	2.754654	77
569	2.755112	2.755189	2.755265	2.755341	2.755417	76
570	2.755875	2.755951	2.756027	2.756103	2.756180	76
571	2.756636	2.756712	2.756788	2.756864	2.756940	76
572	2.757396	2.757472	2.757548	2.757624	2.757700	76

Num	5	6	7	8	9	Diff.
530	2.724685	2.724767	2.724849	2.724931	2.725013	82
531	2.725503	2.725585	2.725667	2.725748	2.725830	82
532	2.726320	2.726401	2.726483	2.726564	2.726646	82
533	2.727134	2.727216	2.727297	2.727379	2.727460	81
534	2.727948	2.728029	2.728110	2.728191	2.728273	81
535	2.728759	2.728841	2.728922	2.729003	2.729084	81
536	2.729570	2.729651	2.729732	2.729813	2.729893	81
537	2.730378	2.730459	2.730540	2.730621	2.730702	81
538	2.731186	2.731266	2.731347	2.731428	2.731508	81
539	2.731991	2.732072	2.732152	2.732233	2.732313	81
540	2.732796	2.732876	2.732956	2.733037	2.733117	80
541	2.733598	2.733679	2.733759	2.733839	2.733919	80
542	2.734400	2.734480	2.734560	2.734640	2.734720	80
543	2.735200	2.735279	2.735359	2.735439	2.735519	80
544	2.735998	2.736078	2.736157	2.736237	2.736317	80
545	2.736795	2.736874	2.736954	2.737034	2.737113	80
546	2.737590	2.737670	2.737749	2.737829	2.737908	79
547	2.738384	2.738463	2.738543	2.738622	2.738701	79
548	2.739177	2.739256	2.739335	2.739414	2.739493	79
549	2.739968	2.740047	2.740126	2.740205	2.740284	79
550	2.740757	2.740836	2.740915	2.740994	2.741073	79
551	2.741546	2.741624	2.741703	2.741782	2.741860	79
552	2.742333	2.742411	2.742489	2.742568	2.742647	79
553	2.743118	2.743196	2.743275	2.743353	2.743431	78
554	2.743902	2.743980	2.744058	2.744136	2.744215	78
555	2.744684	2.744762	2.744840	2.744919	2.744997	78
556	2.745465	2.745543	2.745621	2.745699	2.745777	78
557	2.746245	2.746323	2.746401	2.746479	2.746556	78
558	2.747023	2.747101	2.747179	2.747256	2.747334	78
559	2.747800	2.747878	2.747955	2.748033	2.748110	78
560	2.748576	2.748653	2.748731	2.748808	2.748885	77
561	2.749350	2.749427	2.749504	2.749582	2.749659	77
562	2.750123	2.750200	2.750277	2.750354	2.750431	77
563	2.750894	2.750971	2.751048	2.751125	2.751202	77
564	2.751664	2.751741	2.751818	2.751895	2.751972	77
565	2.752433	2.752509	2.752586	2.752663	2.752740	77
566	2.753200	2.753277	2.753353	2.753430	2.753506	77
567	2.753966	2.754042	2.754119	2.754195	2.754272	77
568	2.754730	2.754807	2.754883	2.754960	2.755036	77
569	2.755494	2.755570	2.755646	2.755722	2.755799	76
570	2.756256	2.756332	2.756408	2.756484	2.756560	76
571	2.757016	2.757092	2.757168	2.757244	2.757320	76
572	2.757775	2.757851	2.757927	2.758003	2.758079	76

Num	0	1	2	3	4	Diff
573	2.758155	2.758230	2.758306	2.758382	2.758458	76
574	2.758912	2.758988	2.759063	2.759139	2.759214	76
575	2.759668	2.759743	2.759819	2.759894	2.759970	75
576	2.760422	2.760498	2.760573	2.760649	2.760724	75
577	2.761176	2.761251	2.761326	2.761402	2.761477	75
578	2.761928	2.762003	2.762078	2.762153	2.762228	75
579	2.762679	2.762754	2.762829	2.762904	2.762978	75
580	2.763428	2.763503	2.763578	2.763652	2.763727	75
581	2.764176	2.764251	2.764326	2.764400	2.764475	75
582	2,764923	2.764998	2.765072	2.765147	2.765221	75
583	2.765669	2.765743	2.765818	2.765892	2.765966	74
584	2.766413	2.766487	2.766562	2.766636	2.766710	74
585	2.767156	2.767230	2.767304	2.767379	2.767453	74
586	2.767898	2.767972	2.768046	2.768120	2.768194	74
587	2.768638	2.768712	2.768786	2.768860	2.768934	74
588	2.769377	2.769451	2.769525	2.769599	2.769673	74
589	2.770115	2.770189	2.770263	2.770336	2.770410	74
590	2.770852	2.770926	2.770999	2.771073	2.771146	74
591	2.771587	2.771661	2.771734	2.771808	2.771881	73
592	2.712322	2.772395	2.772468	2.772542	2.772615	73
593	2.773055	2.773128	2 773201	2.773274	2.773348	73
594	2.773786	2.773860	2.773933	2.774006	2.774079	73
595	2.774517	2.774590	2.774663	2.774736	2.774809	73
596	2.775246	2.775319	2.775392	2.775465	2.775538	73
597	2.775974	2.776047	2.776120	2.776193	2.776265	73
598	2.776701	2.776774	2.776846	2.776919	2.776992	73
599	2.777427	2.777499	2.777572	2.777644	2.777717	72
600	2.778151	2.778224	2.778296	2.778368	2.778441	72
601	2.778874	2.778947	2.779019	2.779091	2.779163	72
602	2.779596	2.779669	2.779741	2.779813	2.779885	72
603	2.780317	2.780389	2.780461	2.780533	2.780605	72
604	2.781037	2.781109	2.781181	2.781253	2.781324	72
605	2.781755	2.781827	2.781899	2.781971	2.782042	72
606	2.782473	2.782544	2.782616	2.782688	2.782759	72
607	2.783189	2.783260	2.783332	2.783403	2.783475	71
608	2.783904	2.783975	2.784046	2.784118	2.784189	71
609	2.784617	2.784689	2.784760	2.784831	2.784902	71
610	2.785330	2.785401	2.785472	2.785543	2.785615	71
611	2.786041	2.786112	2.786183	2.786254	2.786325	71
612	2.786751	2.786822	2.786893	2.786964	2.787035	71
613	2.787460	2.787531	2.787602	2.787673	2.787744	71
614	2.788168	2.788239	2.788310	2.788381	2.788451	71
615	2.788875	2.788946	2.789016	2.789087	2.789158	71

Num	5	6	7	8	9	Diff.
573	2.758533	2.758609	2.758685	2.758761	2.758836	76
574	2.759290	2.759366	2.759441	2.759517	2.759592	76
575	2.760045	2.760121	2.760196	2.760272	2.760347	75
576	2.760799	2.760875	2.760950	2.761025	2.761101	75
577	2.761552	2.761627	2.761702	2.761778	2.761853	75
578	2.762303	2.762378	2.762453	2.762529	2.762604	75
579	2.763053	2.763128	2.763203	2.763278	2.763353	75
580	2.763802	2.763877	2.763952	2.764027	2.764101	75
581	2.764550	2.764624	2.764699	2.764774	2.764848	75
582	2.765296	2.765370	2.765445	2.765520	2.765594	75
583	2.766041	2.766115	2.766190	2.766264	2.766338	74
584	2.766785	2.766859	2.766933	2.767007	2.767082	74
585	2.767527	2.767601	2.767675	2.767749	2.767823	74
586	2.768268	2.768342	2.768416	2.768490	2.768564	74
587	2.769008	2.769082	2.769156	2.769230	2.769303	74
588	2.769746	2.769820	2.769894	2.769968	2.770042	74
589	2.770484	2.770557	2.770631	2.770705	2.770778	74
590	2.771220	2.771293	2.771367	2.771440	2.771514	74
591	2.771955	2.772028	2.772102	2.772175	2.772248	73
592	2.772688	2.772762	2.772835	2.772908	2.772981	73
593	2.773421	2.773494	2.773567	2.773640	2.773713	73
594	2.774152	2.774225	2.774298	2.774371	2.774444	73
595	2.774882	2.774955	2.775028	2.775100	2.775173	73
596	2.775610	2.775683	2.775756	2.775829	2.775902	73
597	2.776338	2.776411	2.776483	2.776556	2.776629	73
598	2.777064	2.777137	2.777209	2.777282	2.777354	73
599	2.777789	2.777862	2.777934	2.778006	2.778079	72
600	2.778513	2.778585	2.778658	2.778730	2.778802	72
601	2.779236	2.779308	2.779380	2.779452	2.779524	72
602	2.779957	2.780029	2.780101	2.780173	2.780245	72
603	2.780677	2.780749	2.780821	2.780893	2.780965	72
604	2.781396	2.781468	2.781540	2.781612	2.781684	72
605	2.782114	2.782186	2.782258	2.782329	2.782401	72
606	2.782831	2.782902	2.782974	2.783046	2.783117	72
607	2.783546	2.783618	2.783689	2.783761	2.783832	71
608	2.784261	2.784332	2.784403	2.784475	2.784546	71
609	2.784974	2.785045	2.785116	2.785187	2.785259	71
610	2.785686	2.785757	2.785828	2.785899	2.785970	71
611	2.786396	2.786467	2.786538	2.786609	2.786680	71
612	2.787106	2.787177	2.787248	2.787319	2.787390	71
613	2.787815	2.787885	2.787956	2.788027	2.788098	71
614	2.788522	2.788593	2.788663	2.788734	2.788804	71
615	2.789228	2.789299	2.789369	2.789440	2.789510	71

Num	0	1	2	3	4	Diff.
616	2.789581	2.789651	2.789722	2.789792	2.789863	70
617	2.790285	2.790356	2.790426	2.790496	2.790567	70
618	2.790989	2.791059	2.791129	2.791199	2.791269	70
619	2.791691	2.791761	2.791831	2.791901	2.791971	70
620	2.792392	2.792462	2.792532	2.792602	2.792672	70
621	2.793092	2.793162	2.793231	2.793301	2.793371	70
622	2.793790	2.793860	2.793930	2.794000	2.794070	70
623	2.794488	2.794558	2.794627	2.794697	2.794767	70
624	2.795185	2.795254	2.795324	2.795393	2.795463	69
625	2.795880	2.795949	2.796019	2.796088	2.796158	69
626	2.796574	2.796644	2.796713	2.796782	2.796852	69
627	2.797268	2.797337	2.797406	2.797475	2.797545	69
628	2.797960	2.798029	2.798098	2.798167	2.798237	69
629	2.798651	2.798720	2.798789	2.798858	2 798927	69
630	2.799341	2.799409	2.799478	2.799547	2.799616	69
631	2.800029	2.800098	2.800166	2.800236	2.800305	69
632	2.800717	2.800786	2.800854	2.800923	2.800992	69
633	2.801404	2.801472	2.801541	2.801609	2.801678	69
634	2.802089	2.802158	2.802226	2.802295	2.802363	68
635	2.802774	2 802842	2.802910	2.802979	2.803047	68
636	2.803457	2.803525	2 803594	2.803662	2.803730	68
637	2.804139	2.804208	2.804276	2.804344	2.804412	68
638	2.804821	2.804889	2.804957	2.805025	2.805093	68
639	2.805501	2.805569	2.805637	2.805705	2.805773	68
640	2.806180	2.806248	2.806316	2.806384	2.806451	68
641	2.806858	2.806926	2.806994	2.807061	2.807129	68
642	2.807535	2.807603	2.807670	2.807738	2.807806	68
643	2.808211	2.308279	2.808346	2.808414	2.808481	67
644	2.808886	2.808953	2.809021	2.809088	2.809155	67
645	2.809560	2.809627	2.809694	2.809762	2.809829	67
646	2.810233	2.810300	2.810367	2.810434	2.810501	67
647	2.810904	2.810971	2.811038	2.811106	2.811173	67
648	2.811575	2.811642	2.811709	2.811776	2.811843	67
649	2.812245	2.812312	2.812378	2.812445	2.812512	67
650	2.812913	2.812980	2.813047	2.813114	2.813180	67
651	2.813581	2.813648	2.813714	2.813781	2.813848	67
652	2.814248	2.814314	2.814381	2.814447	2.814514	67
653	2.814913	2.814980	2.815046	2.815113	2.815179	66
654	2.815578	2.815644	2.815710	2.815777	2.815843	66
655	2.816241	2.816308	2.816374	2.816440	2.816506	66
656	2.816904	2.816970	2.817036	2.817102	2.817169	66
657	2.817565	2.817631	2.817698	2.817764	2.817830	66
658	2.818226	2.818292	2.818358	2.818424	2.818490	66

Num	5	6	7	8	9	Diff
616	2.789933	2.790003	2.790074	2.790144	2.790215	70
617	2.790637	2.790707	2.790778	2.790848	2.790918	70
618	2.791340	2.791410	2.791480	2.791550	2.791620	70
619	2.792041	2.792111	2.792181	2.792252	2.792322	70
620	2.792742	2.792812	2.792882	2.792952	2.793022	70
621	2.793441	2.793511	2.793581	2.793651	2.793721	70
622	2.794139	2.794209	2.794279	2.794349	2.794418	70
623	2.794836	2.794906	2.794976	2.795045	2.795115	70
624	2.795532	2.795602	2.795671	2.795741	2.795810	69
625	2.796227	2.796297	2.796366	2.796436	2.796505	69
626	2.796921	2.796990	2.797060	2.797129	2.797198	69
627	2.797614	2.797683	2.797752	2.797821	2.797890	69
628	2.798305	2.798374	2.798443	2.798512	2.798582	69
629	2.798996	2.799065	2.799134	2.799203	2.799272	69
630	2.799685	2.799754	2.799823	2.799892	2.799960	69
631	2.800373	2.800442	2.800511	2.800580	2.800648	69
632	2.801060	2.801129	2.801198	2.801267	2.801335	69
633	2.801747	2.801815	2.801884	2 801952	2.802021	69
634	2.802432	2.802500	2.802568	2.802637	2.802705	68
635	2.803116	2.803184	2.803252	2.803321	2.803389	68
636	2.803798	2.803867	2.803935	2.804003	2.804071	68
637	2.804480	2.804548	2.804616	2.804685	2.804753	68
638	2.805161	2.805229	2.805297	2.805365	2.805433	68
639	2.805840	2.805908	2.805976	2.806044	2.806112	68
640	2.806519	2.806587	2.806655	2.806723	2.806790	68
641	2.807197	2.807264	2.807332	2.807400	2.807467	68
642	2.807873	2.807941	2.808008	2.808076	2.808143	68
643	2.808548	2.808616	2.808683	2.808751	2.808818	67
644	2.809223	2.809290	2.809358	2.809425	2.809492	67
645	2.809896	2.809963	2.810031	2.810098	2.810165	67
646	2.810568	2.810636	2.810703	2.810770	2.810837	67
647	2.811240	2.811307	2.811374	2.811441	2.811508	67
648	2.811910	2.811977	2.812044	2.812111	2.812178	67
649	2.812579	2.812646	2.812713	2.812780	2.812846	67
650	2.813247	2.813314	2.813381	2.813447	2.813514	67
651	2.813914	2.813981	2.814048	2.814114	2.814181	67
652	2.814580	2.814647	2.814714	2.814780	2.814847	67
653	2.815246	2.815312	2.815378	2.815445	2.815511	66
654	2.815910	2.815976	2.816042	2.816109	2.816175	66
655	2.816573	2.816639	2.816705	2.816771	2.816838	66
656	2.817235	2.817301	2.817367	2.817433	2.817499	66
757	2.817896	2.817962	2.818028	2.818094	2.818160	66
758	2.818556	2.818622	2.818688	2.818754	2.818819	66

Num	0	1	2	3	4	Diff.
616	2.789581	2.789651	2.789722	2.789792	2.789863	70
617	2.790285	2.790356	2.790426	2.790496	2.790567	70
618	2.790989	2.791059	2.791129	2.791199	2.791269	70
619	2.791691	2.791761	2.791831	2.791901	2.791971	70
620	2.792392	2.792462	2.792532	2.792602	2.792672	70
621	2.793092	2.793162	2.793231	2.793301	2.793371	70
622	2.793790	2.793860	2.793930	2.794000	2.794070	70
623	2.794488	2.794558	2.794627	2.794697	2.794767	70
624	2.795185	2.795254	2.795324	2.795393	2.795463	69
625	2,795880	2.795949	2.796019	2.796088	2.796158	69
626	2.796574	2.796644	2.796713	2.796782	2.796852	69
627	2.797268	2.797337	2.797406	2.797475	2.797545	69
628	2.797960	2.798029	2.798098	2.798167	2.798237	69
629	2.798651	2.798720	2.798789	2.798858	2 798927	69
630	2.799341	2.799409	2.799478	2.799547	2.799616	69
631	2.800029	2 800098	2.800166	2.800236	2.800305	69
632	2.800717	2.800786	2.800854	2.800923	2.800992	69
633	2.801404	2.801472	2.801541	2.801609	2.801678	69
634	2.802089	2.802158	2.802226	2.802295	2.802363	68
635	2.802774	2 802842	2.802910	2.802979	2.803047	68
636	2.803457	2.803525	2 803594	2.803662	2.803730	68
637	2.804139	2.804208	2.804276	2.804344	2.804412	68
638	2.804821	2.804889	2.804957	2.805025	2.805093	68
639	2.805501	2.805569	2.805637	2.805705	2.805773	68
640	2.806180	2.806248	2.806316	2.806384	2.806451	68
641	2.806858	2.806926	2.806994	2.807061	2.807129	68
642	2.807535	2.807603	2.807670	2.807738	2.807806	68
643	2.808211	2.308279	2.808346	2.808414	2.808481	67
644	2.808886	2.808953	2.809021	2.809088	2.809155	67
645	2.809560	2.809627	2.809694	2.809762	2.809829	67
646	2.810233	2.810300	2.810367	2.810434	2.810501	67
647	2.810904	2.810971	2.811038	2.811106	2.811173	67
648	2.811575	2.811642	2.811709	2.811776	2.811843	67
649	2.812245	2.812312	2.812378	2.812445	2.812512	67
650	2.812913	2.812980	2.813047	2.813114	2.813180	67
651	2.813581	2.813648	2.813714	2.813781	2.813848	67
652	2.814248	2.814314	2.814381	2.814447	2.814514	67
653	2.814913	2.814980	2.815046	2.815113	2.815179	66
654	2.815578	2.815644	2.815710	2.815777	2.815843	66
655	2.816241	2.816308	2.816374	2.816440	2.816506	66
656	2.816904	2.816970	2.817036	2.817102	2.817169	66
657	2.817565	2.817631	2.817698	2.817764	2.817830	66
658	2.818226	2.818292	2.818358	2.818424	2.818490	66

Num	5	6	7	8	9	Diff
616	2.789933	2.790003	2.790074	2.790144	2.790215	70
617	2.790637	2.790707	2.790778	2.790848	2.790918	70
618	2.791340	2.791410	2.791480	2.791550	2.791620	70
619	2.792041	2.792111	2.792181	2.792252	2.792322	70
620	2.792742	2.792812	2.792882	2.792952	2.793022	70
621	2.793441	2.793511	2.793581	2.793651	2.793721	70
622	2.794139	2.794209	2.794279	2.794349	2.794418	70
623	2.794836	2.794906	2.794976	2.795045	2.795115	70
624	2.795532	2.795602	2.795671	2.795741	2.795810	69
625	2.796227	2.796297	2.796366	2.796436	2.796505	69
626	2.796921	2.796990	2.797060	2.797129	2.797198	69
627	2.797614	2.797683	2.797752	2.797821	2.797890	69
628	2.798305	2.798374	2.798443	2.798512	2.798582	69
629	2.798996	2.799065	2.799134	2.799203	2.799272	69
630	2.799685	2.799754	2.799823	2.799892	2.799960	69
631	2.800373	2.800442	2.800511	2.800580	2.800648	69
632	2.801060	2.801129	2.801198	2.801267	2.801335	69
633	2.801747	2.801815	2.801884	2 801952	2.802021	69
634	2.802432	2.802500	2.802568	2.802637	2.802705	68
635	2.803116	2.803184	2.803252	2.803321	2.803389	68
636	2.803798	2.803867	2.803935	2.804003	2.804071	68
637	2.804480	2.804548	2.804616	2.804685	2.804753	68
638	2.805161	2.805229	2.805297	2.805365	2.805433	68
639	2.805840	2.805908	2.805976	2.806044	2.806112	68
640	2.806519	2.806587	2.806655	2.806723	2.806790	68
641	2.807197	2.807264	2.807332	2.807400	2.807467	68
642	2.807873	2.807941	2.808008	2.808076	2.808143	68
643	2.808548	2.808616	2.808683	2.808751	2.808818	67
644	2.809223	2.809290	2.809358	2.809425	2.809492	67
645	2.809896	2.809963	2.810031	2.810098	2.810165	67
646	2.810568	2.810636	2.810703	2.810770	2.810837	67
647	2.811240	2.811307	2.811374	2.811441	2.811508	67
648	2.811910	2.811977	2.812044	2.812111	2.812178	67
649	2.812579	2.812646	2.812713	2.812780	2.812846	67
650	2.813247	2.813314	2.813381	2.813447	2.813514	67
651	2.813914	2.813981	2.814048	2.814114	2.814181	67
652	2.814580	2.814647	2.814714	2.814780	2.814847	67
653	2.815246	2.815312	2.815378	2.815445	2.815511	66
654	2.815910	2.815976	2.816042	2.816109	2.816175	66
655	2.816573	2.816639	2.816705	2.816771	2.816838	66
656	2.817235	2.817301	2.817367	2.817433	2.817499	66
757	2.817896	2.817962	2.818028	2.818094	2.818160	66
758	2.818556	2.818622	2.818688	2.818754	2.818819	66

Num	0	1	2	3	4	Dif.
659	2.818885	2.818951	2.819017	2.819083	2.819149	66
660	2.819544	2.819610	2.819675	2.819741	2.819807	66
661	2.820201	2.820267	2.820333	2.820398	2.820464	66
662	2.820858	2.820924	2.820989	2.821055	2.821120	66
663	2.821513	2.821579	2.821644	2.821710	2.821775	65
664	2.822168	2.822233	2.822299	2.822364	2.822430	65
665	2.822822	2.822887	2.822952	2.823017	2.823083	65
666	2.823474	2.823539	2.823605	2.823670	2.823735	65
667	2.824126	2.824191	2.824256	2.824321	2.824386	65
668	2.824776	2.824841	2.824906	2.824971	2.825036	65
669	2.825426	2.825491	2.825556	2.825621	2.825686	65
670	2.826075	2.826140	2.826204	2.826269	2.826334	65
671	2.826722	2.826787	2.826852	2.826917	2.826981	65
672	2.827369	2.827434	2.827498	2.827563	2.827628	65
673	2.828015	2.828080	2.828144	2.828209	2.828273	64
674	2.828660	2.828724	2.828789	2.828853	2.828918	64
675	2.829304	2.829368	2.829432	2.829497	2.829561	64
676	2.829947	2.830011	2.830075	2.830139	2.830204	64
677	2.830589	2.830653	2.830717	2.830781	2.830845	64
678	2.831230	2.831294	2.831358	2.831422	2.831486	64
679	2.831870	2.831934	2.831998	2.832062	2.832125	64
680	2.832509	2.832573	2.832637	2.832700	2.832764	64
681	2.833147	2.833211	2.833275	2.833338	2.833402	64
682	2.833784	2.833848	2.833912	2.833975	2.834039	64
683	2.834421	2.834484	2.834548	2.834611	2.834675	64
684	2.835056	2.835120	2.835183	2.835246	2.835310	63
685	2.835691	2.835754	2.835817	2.835881	2.835944	63
686	2.836324	2.836387	2.836451	2.836514	2.836577	63
687	2.836957	2.837020	2.837083	2.837146	2.837209	63
688	2.837588	2.837652	2.837715	2.837778	2.837841	63
689	2.838219	2.838282	2.838345	2.838408	2.838471	63
690	2.838849	2.838912	2.838975	2.839038	2.839101	63
691	2.839478	2.839541	2.839604	2.839667	2.839729	63
692	2.840106	2.840169	2.840232	2.840294	2.840357	63
693	2.840733	2.840796	2.840859	2.840921	2.840984	63
694	2.841359	2.841422	2.841485	2.841547	2.841610	63
695	2.841985	2.842047	2.842110	2.842172	2.842235	62
696	2.842609	2.842672	2.842734	2.842796	2.842859	62
697	2.843233	2.843295	2.843357	2.843420	2.843482	62
698	2.843855	2.843918	2.843980	2.844042	2.844104	62
699	2.844477	2.844539	2.844601	2.844663	2.844726	62
700	2.845098	2.845160	2.845222	2.845284	2.845346	62
701	2.845718	2.845780	2.845842	2.845904	2.845966	62

Num	5	6	7	8	9	Diff
659	2.819215	2.819281	2.819346	2.819412	2.819478	66
660	2.819873	2.819939	2.820004	2.820070	2.820136	66
661	2.820530	2.820595	2.820661	2.820727	2.820792	66
662	2.821186	2.821251	2.821317	2.821382	2.821448	66
663	2.821841	2.821906	2.821972	2.822037	2.822103	65
664	2.822495	2.822560	2.822626	2.822691	2.822756	65
665	2.823148	2.823213	2.823279	2.823344	2.823409	65
666	2.823800	2.823865	2.823930	2.823996	2.824061	65
667	2.824451	2.824516	2.824581	2.824646	2.824711	65
668	2.825101	2.825166	2.825231	2.825296	2.825361	65
669	2.825751	2.825815	2.825880	2.825945	2.826010	65
670	2.826399	2.826464	2.826528	2.826593	2.826658	65
671	2.827046	2.827111	2.827175	2.827240	2.827305	65
672	2.827692	2.827757	2.827821	2.827886	2.827950	65
673	2.828338	2.828402	2.828467	2.828531	2.828595	64
674	2.828982	2.829046	2.829111	2.829175	2.829239	64
675	2.829625	2.829690	2.829754	2.829818	2.829882	64
676	2.830268	2.830332	2.830396	2.830460	2.830524	64
677	2.830909	2.830973	2.831037	2.831102	2.831166	64
678	2.831550	2.831614	2.831678	2.831742	2.831806	64
679	2.832189	2.832253	2.832317	2.832381	2.832445	64
680	2.832828	2.832892	2.832956	2.833019	2.833083	64
681	2.833466	2.833530	2.833593	2.833657	2.833721	64
682	2.834103	2.834166	2.834230	2.834293	2.834357	64
683	2.834738	2.834802	2.834866	2.834929	2.834993	64
684	2.835373	2.835437	2.835500	2.835564	2.835627	63
685	2.836007	2.836071	2.836134	2.836197	2.836261	63
686	2.836640	2.836704	2.836767	2.836830	2.836893	63
687	2.837273	2.837336	2.837399	2.837462	2.837525	63
688	2.837904	2.837967	2.838030	2.838093	2.838156	63
689	2.838534	2.838597	2.838660	2.838723	2.838786	63
690	2.839164	2.839227	2.839289	2.839352	2.839415	63
691	2.839792	2.839855	2.839918	2.839981	2.840043	63
692	2.840420	2.840482	2.840545	2.840608	2.840671	63
693	2.841046	2.841109	2.841172	2.841234	2.841297	63
694	2.841672	2.841735	2.841797	2.841860	2.841922	63
695	2.842297	2.842360	2.842422	2.842484	2.842547	62
696	2.842921	2.842983	2.843046	2.843108	2.843170	62
697	2.843544	2.843606	2.843669	2.843731	2.843793	62
698	2.844166	2.844229	2.844291	2.844353	2.844415	62
699	2.844788	2.844850	2.844912	2.844974	2.845036	62
700	2.845408	2.845470	2.845532	2.845594	2.845656	62
701	2.846028	2.846090	2.846151	2.846213	2.846275	62

Num	0	1	2	3	4	Diff.
702	2.846337	2.846399	2.846461	2.846523	2.846584	62
703	2.846955	2.847017	2.847079	2.847141	2.847202	62
704	2.847573	2.847634	2.847696	2.847758	2.847819	62
705	2.848189	2.848251	2.848312	2.848374	2.848435	62
706	2.848805	2.848866	2.848928	2.848989	2.849051	61
707	2.849419	2.849481	2.849542	2.849604	2.849665	61
708	2.850033	2.850095	2.850156	2.850217	2.850279	61
709	2.850646	2.850707	2.850769	2.850830	2.850891	61
710	2.851258	2.851319	2.851381	2.851442	2.851503	61
711	2.851870	2.851931	2.851992	2.852053	2.852114	61
712	2.852480	2.852541	2.852602	2.852663	2.852724	61
713	2.853089	2.853150	2.853211	2.853272	2.853333	61
714	2.853698	2.853759	2.853820	2.853881	2.853941	61
715	2.854306	2.854367	2.854427	2.854488	2.854549	61
716	2.854913	2.854974	2.855034	2.855095	2.855156	61
717	2.855519	2.855580	2.855640	2.855701	2.855761	60
718	2.856124	2.856185	2.856245	2.856306	2.856366	60
719	2.856729	2.856789	2.856850	2.856910	2.856970	60
720	2.857332	2.857393	2.857453	2.857513	2.857574	60
721	2.857935	2.857995	2.858056	2.858116	2.858176	60
722	2.858537	2.858597	2.858657	2.858718	2.858778	60
723	2.859138	2.859198	2.859258	2.859318	2.859378	60
724	2.859739	2.859798	2.859858	2.859918	2.859978	60
725	2.860338	2.860398	2.860458	2.860518	2.860578	60
726	2.860937	2.860996	2.861056	2.861116	2.861176	60
727	2.861534	2.861594	2.861654	2.861714	2.861773	60
728	2.862131	2.862191	2.862251	2.862310	2.862370	60
729	2.862727	2.862787	2.862847	2.862906	2.862966	60
730	2.863323	2.863382	2.863442	2.863501	2.863561	59
731	2.863917	2.863977	2.864036	2.864096	2.864155	59
732	2.864511	2.864570	2.864630	2.864689	2.864748	59
733	2.865104	2.865163	2.865222	2.865282	2.865341	59
734	2.865696	2.865755	2.865814	2.865873	2.865933	59
735	2.866287	2.866346	2.866405	2.866465	2.866524	59
736	2.866878	2.866937	2.866996	2.867055	2.867114	59
737	2.867467	2.867526	2.867585	2.867644	2.867703	59
738	2.868056	2.868115	2.868174	2.868233	2.868292	59
739	2.868644	2.868703	2.868762	2.868821	2.868879	59
740	2.869232	2.869290	2.869349	2.869408	2.869466	59
741	2.869818	2.869877	2.869935	2.869994	2.870053	59
742	2.870404	2.870462	2.870521	2.870579	2.870638	58
743	2.870989	2.871047	2.871106	2.871164	2.871223	58
744	2.871573	2.871631	2.871690	2.871748	2.871806	58

Num	5	6	7	8	9	Diff
702	2.846646	2.846708	2.846770	2.846832	2.846893	62
703	2.847264	2.847326	2.847388	2.847449	2.847511	62
704	2.847881	2.847943	2.848004	2.848066	2.848127	62
705	2.848497	2.848559	2.848620	2.848682	2.848743	62
706	2.849112	2.849174	2.849235	2.849296	2.849358	61
707	2.849726	2.849788	2.849849	2.849911	2.849972	61
708	2.850340	2.850401	2.850462	2.850524	2.850585	61
709	2.850952	2.851014	2.851075	2.851136	2.851197	61
710	2.851564	2.851625	2.851686	2.851747	2.851808	61
711	2.852175	2.852236	2.852297	2.852358	2.852419	61
712	2.852785	2.852846	2.852907	2.852968	2.853029	61
713	2.853394	2.853455	2.853516	2.853576	2.853637	61
714	2.854002	2.854063	2.854124	2.854184	2.854245	61
715	2.854610	2.854670	2.854731	2.854792	2.854852	61
716	2.855216	2.855277	2.855337	2.855398	2.855459	61
717	2.855822	2.855882	2.855943	2.856003	2.856064	60
718	2.856427	2.856487	2.856548	2.856608	2.856668	60
719	2.857031	2.857091	2.857151	2.857212	2.857272	60
720	2.857634	2.857694	2.857754	2.857815	2.857875	60
721	2.858236	2.858296	2.858357	2.858417	2.858477	60
722	2.858838	2.858898	2.858958	2.859018	2.859078	60
723	2.859438	2.859498	2.859559	2.859619	2.859679	60
724	2.860038	2.860098	2.860158	2.860218	2.860278	60
725	2.860637	2.860697	2.860757	2.860817	2.860877	60
726	2.861236	2.861295	2.861355	2.861415	2.861475	60
727	2.861833	2.861893	2.861952	2.862012	2.862072	60
728	2.862430	2.862489	2.862549	2.862608	2.862668	60
729	2.863025	2.863085	2.863144	2.863204	2.863263	60
730	2.863620	2.863680	2.863739	2.863798	2.863858	59
731	2.864214	2.864274	2.864333	2.864392	2.864452	59
732	2.864808	2.864867	2.864926	2.864985	2.865045	59
733	2.865400	2.865459	2.865518	2.865578	2.865637	59
734	2.865992	2.866051	2.866110	2.866169	2.866228	59
735	2.866583	2.866642	2.866701	2.866760	2.866819	59
736	2.867173	2.867232	2.867291	2.867350	2.867409	59
737	2.867762	2.867821	2.867880	2.867939	2.867997	59
738	2.868350	2.868409	2.868468	2.868527	2.868586	59
739	2.868938	2.868997	2.869056	2.869114	2.869173	59
740	2.869525	2.869584	2.869642	2.869701	2.869760	59
741	2.870111	2.870170	2.870228	2.870287	2.870345	59
742	2.870696	2.870755	2.870813	2.870872	2.870930	58
743	2.871281	2.871339	2.871398	2.871456	2.871515	58
744	2.871865	2.871923	2.871981	2.872040	2.872098	58

Num	0	1	2	3	4	Diff.
745	2.872156	2.872215	2.872273	2.872331	2.872389	58
746	2.872739	2.872797	2.872855	2.872913	2.872972	58
747	2.873321	2.873379	2.873437	2.873495	2.873553	58
748	2.873902	2.873960	2.874018	2.874076	2.874134	58
749	2.874482	2.874540	2.874598	2.874656	2.874714	58
750	2.875061	2.875119	2.875177	2.875235	2.875293	58
751	2.875640	2.875698	2.875756	2.875815	2.875871	58
752	2.876218	2.876276	2.876333	2.876391	2.876449	58
753	2.876795	2.876853	2.876910	2.876968	2.877026	58
754	2.877371	2.877429	2.877486	2.877544	2.877602	58
755	2.877947	2.878004	2.878062	2.878119	2.878177	57
756	2.878522	2.878579	2.878637	2.878694	2.878751	57
757	2.879096	2.879153	2.879211	2.879268	2.879325	57
758	2.879669	2.879726	2.879784	2.879841	2.879898	57
759	2.880242	2.880299	2.880356	2.880413	2.880471	57
760	2.880814	2.880871	2.880928	2.880985	2.881042	57
761	2.881385	2.881442	2.881499	2.881556	2.881613	57
762	2.881955	2.882012	2.882069	2.882126	2.882183	57
763	2.882524	2.882581	2.882638	2.882695	2.882752	57
764	2.883093	2.883150	2.883207	2.883264	2.883321	57
765	2.883661	2.883718	2.883775	2.883832	2.883889	57
766	2.884229	2.884285	2.884342	2.884399	2.884455	57
767	2.884795	2.884852	2.884909	2.884965	2.885022	57
768	2.885361	2.885418	2.885474	2.885531	2.885587	57
769	2.885926	2.885983	2.886039	2.886096	2.886152	56
770	2.886491	2.886547	2.886603	2.886660	2.886716	56
771	2.887054	2.887111	2.887167	2.887223	2.887280	56
772	2.887617	2.887673	2.887730	2.887786	2.887842	56
773	2.888179	2.888236	2.888292	2.888348	2.888404	56
774	2.888741	2.888797	2.888853	2.888909	2.888965	56
775	2.889302	2.889358	2.889414	2.889470	2.889526	56
776	2.889862	2.889918	2.889974	2.890030	2.890089	56
777	2.890421	2.890477	2.890533	2.890586	2.890644	56
778	2.890980	2.891035	2.891091	2.891147	2.891203	56
779	2.891537	2.891593	2.891649	2.891705	2.891760	56
780	2.892095	2.892150	2.892206	2.892262	2.892317	56
781	2.892651	2.892707	2.892762	2.892818	2.892873	56
782	2.893207	2.893262	2.893318	2.893373	2.893429	56
783	2.893762	2.893817	2.893873	2.893928	2.893984	55
784	2.894316	2.894371	2.894427	2.894482	2.894538	55
785	2.894870	2.894925	2.894980	2.895036	2.895091	55
786	2.895422	2.895478	2.895533	2.895588	2.895643	55
787	2.895975	2.896030	2.896085	2.896140	2.896195	55

Num	5	6	7	8	9	Diff.
745	2.872448	2.872506	2.872564	2.872622	2.872681	58
746	2.873030	2.873088	2.873146	2.873204	2.873262	58
747	2.873611	2.873669	2.873727	2.873785	2.873843	58
748	2.874192	2.874250	2.874308	2.874366	2.874424	58
749	2.874772	2.874830	2.874887	2.874945	2.875003	58
750	2.875351	2.875409	2.875466	2.875524	2.875582	58
751	2.875929	2.875987	2.876045	2.876102	2.876160	58
752	2.876506	2.876564	2.876622	2.876680	2.876737	58
753	2.877083	2.877141	2.877198	2.877256	2.877314	58
754	2.877659	2.877717	2.877774	2.877832	2.877889	58
755	2.878234	2.878292	2.878349	2.878407	2.878464	57
756	2.878809	2.878866	2.878924	2.878981	2.879038	57
757	2.879383	2.879440	2.879497	2.879555	2.879612	57
758	2.879956	2.880013	2.880070	2.880127	2.880185	57
759	2.880528	2.880585	2.880642	2.880699	2.880756	57
760	2.881099	2.881156	2.881213	2.881270	2.881328	57
761	2.881670	2.881727	2.881784	2.881841	2.881898	57
762	2.882240	2.882297	2.882354	2.882411	2.882468	57
763	2.882809	2.882866	2.882923	2.882980	2.883036	57
764	2.883377	2.883434	2.883491	2.883548	2.883605	57
765	2.883945	2.884002	2.884059	2.884115	2.884172	57
766	2.884512	2.884569	2.884625	2.884682	2.884739	57
767	2.885078	2.885135	2.885191	2.885248	2.885305	57
768	2.885644	2.885700	2.885757	2.885813	2.885870	57
769	2.886209	2.886265	2.886321	2.886378	2.886434	56
770	2.886773	2.886829	2.886885	2.886942	2.886998	56
771	2.887336	2.887392	2.887448	2.887505	2.887561	56
772	2.887898	2.887955	2.888011	2.888068	2.888123	56
773	2.888460	2.888516	2.888573	2.888629	2.888685	56
774	2.889021	2.889077	2.889134	2.889190	2.889246	56
775	2.889582	2.889638	2.889694	2.889750	2.889806	56
776	2.890141	2.890197	2.890253	2.890309	2.890365	56
777	2.890700	2.890756	2.890812	2.890868	2.890924	56
778	2.891259	2.891314	2.891370	2.891426	2.891482	56
779	2.891816	2.891872	2.891927	2.891983	2.892039	56
780	2.892373	2.892428	2.892484	2.892540	2.892595	56
781	2.892929	2.892985	2.893040	2.893096	2.893151	56
782	2.893484	2.893540	2.893595	2.893651	2.893706	56
783	2.894039	2.894094	2.894150	2.894205	2.894261	55
784	2.894593	2.894648	2.894704	2.894759	2.894814	55
785	2.895146	2.895201	2.895257	2.895312	2.895367	55
786	2.895699	2.895754	2.895809	2.895864	2.895919	55
787	2.896251	2.896306	2.896361	2.896416	2.896471	55

Num	0	1	2	3	4	Diff.
788	2.896526	2.896581	2.896636	2.896691	2.896747	55
789	2.897077	2.897132	2.897187	2.897242	2.897297	55
790	2.897627	2.897682	2.897737	2.897792	2.897847	55
791	2.898176	2.898231	2.898286	2.898341	2.898396	55
792	2.898725	2.898780	2.898835	2.898890	2.898944	55
793	2.899273	2.899328	2.899383	2.899437	2.899492	55
794	2.899820	2.899875	2.899930	2.899985	2.900039	55
795	2.900367	2.900422	2.900476	2.900531	2.900586	55
796	2.900913	2.900968	2.901022	2.901077	2.901131	55
797	2.901458	2.901513	2.901567	2.901622	2.901676	55
798	2.902003	2.902057	2.902112	2.902166	2.902220	54
799	2.902547	2.902601	2.902655	2.902710	2.902764	54
800	2.903090	2.903144	2.903198	2.903253	2.903307	54
801	2.903632	2.903687	2.903741	2.903795	2.903849	54
802	2.904174	2.904228	2.904283	2.904337	2.904391	54
803	2.904715	2.904770	2.904824	2.904878	2.904931	54
804	2.905256	2.905310	2.905364	2.905418	2.905472	54
805	2.905796	2.905850	2.905904	2.905958	2.906012	54
806	2.906335	2.906389	2.906443	2.906497	2.906550	54
807	2.906873	2.906927	2.906981	2.907035	2.907089	54
808	2.907411	2.907465	2.907519	2.907573	2.907626	54
809	2.907948	2.908002	2.908056	2.908109	2.908163	54
810	2.908485	2.908539	2.908592	2.908646	2.908699	54
811	2.909021	2.909074	2.909128	2.909181	2.909235	53
812	2.909556	2.909609	2.909663	2.909716	2.909770	53
813	2.910090	2.910144	2.910197	2.910251	2.910304	53
814	2.910624	2.910678	2.910731	2.910784	2.910838	53
815	2.911158	2.911211	2.911264	2.911317	2.911371	53
816	2.911690	2.911743	2.911797	2.911850	2.911903	53
817	2.912222	2.912275	2.912328	2.912381	2.912435	53
818	2.912753	2.912806	2.912859	2.912912	2.912966	53
819	2.913284	2.913337	2.913390	2.913443	2.913496	53
820	2.913814	2.913867	2.913920	2.913973	2.914026	53
821	2.914343	2.914396	2.914449	2.914502	2.914555	53
822	2.914872	2.914925	2.914977	2.915030	2.915083	53
823	2.915400	2.915453	2.915505	2.915558	2.915611	53
824	2.915927	2.915980	2.916033	2.916085	2.916138	53
825	2.916454	2.916507	2.916559	2.916612	2.916664	53
826	2.916980	2.917033	2.917085	2.917138	2.917190	53
827	2.917505	2.917558	2.917610	2.917663	2.917715	52
828	2.918030	2.918083	2.918135	2.918188	2.918240	52
829	2.918555	2.918607	2.918659	2.918712	2.918764	52
830	2.919078	2.919130	2.919183	2.919236	2.919287	52

Num	5	6	7	8	9	Diff
788	2.896802	2.896857	2.896912	2.896967	2.897022	55
789	2.897352	2.897407	2.897462	2.897517	2.897572	55
790	2.897902	2.897957	2.898012	2.898067	2.898122	55
791	2.898451	2.898506	2.898561	2.898615	2.898670	55
792	2.898999	2.899054	2.899109	2.899164	2.899218	55
793	2.899547	2.899602	2.899650	2.899711	2.899766	55
794	2.900094	2.900149	2.900203	2.900258	2.900312	55
795	2.900640	2.900695	2.900749	2.900804	2.900858	55
796	2.901186	2.901240	2.901295	2.901349	2.901404	55
797	2.901731	2.901785	2.901840	2.901894	2.901948	54
798	2.902275	2.902329	2.902384	2.902438	2.902492	54
799	2.902818	2.902873	2.902927	2.902981	2.903036	54
800	2.903361	2.903416	2.903470	2.903524	2.903578	54
801	2.903903	2.903958	2.904012	2.904066	2.904120	54
802	2.904445	2.904499	2.904553	2.904607	2.904661	54
803	2.904986	2.905040	2.905094	2.905148	2.905202	54
804	2.905526	2.905580	2.905634	2.905688	2.905742	54
805	2.906065	2.906119	2.906173	2.906227	2.906281	54
806	2.906604	2.906658	2.906712	2.906766	2.906820	54
807	2.907142	2.907196	2.907250	2.907304	2.907358	54
808	2.907680	2.907734	2.907787	2.907841	2.907895	54
809	2.908217	2.908270	2.908324	2.908378	2.908431	54
810	2.908753	2.908807	2.908860	2.908914	2.908967	54
811	2.909288	2.909342	2.909395	2.909419	2.909502	54
812	2.909823	2.909877	2.909930	2.909984	2.910037	53
813	2.910358	2.910411	2.910464	2.910518	2.910571	53
814	2.910891	2.910944	2.910998	2.911051	2.911104	53
815	2.911424	2.911477	2.911530	2.911584	2.911637	53
816	2.911956	2.912009	2.912063	2.912116	2.912169	53
817	2.912488	2.912541	2.912594	2.912647	2.912700	53
818	2.913019	2.913072	2.913125	2.913178	2.913231	53
819	2.913549	2.913602	2.913655	2.913708	2.913761	53
820	2.914079	2.914131	2.914184	2.914237	2.914290	53
821	2.914608	2.914660	2.914713	2.914766	2.914819	53
822	2.915136	2.915189	2.915241	2.915294	2.915347	53
823	2.915664	2.915716	2.915769	2.915822	2.915874	53
824	2.916191	2.916243	2.916296	2.916349	2.916401	53
825	2.916717	2.916770	2.916822	2.916875	2.916927	53
826	2.917243	2.917295	2.917348	2.917400	2.917453	53
827	2.917768	2.917820	2.917873	2.917925	2.917978	52
828	2.918292	2.918345	2.918397	2.918450	2.918502	52
829	2.918816	2.918809	2.918921	2.918973	2.919026	52
830	2.919340	2.919392	2.919444	2.919496	2.919549	52

Num	0	1	2	3	4	Diff.
831	2.919601	2.919653	2.919705	2.919758	2.919810	52
832	2.920123	2.920175	2.920228	2.920280	2.920332	52
833	2.920645	2.920697	2.920749	2.920801	2.920853	52
834	2.921166	2.921218	2.921270	2.921322	2.921374	52
835	2.921686	2.921738	2.921790	2.921842	2.921894	52
836	2.922206	2.922258	2.922310	2.922362	2.922414	52
837	2.922725	2.922777	2.922829	2.922881	2.922933	52
838	2.923244	2.923296	2.923348	2.923399	2.923451	52
839	2.923762	2.923814	2.923865	2.923917	2.923969	52
840	2.924279	2.924331	2.924383	2.924434	2.924486	52
841	2.924796	2.924848	2.924899	2.924951	2.925002	52
842	2.925312	2.925364	2.925415	2.925467	2.925518	52
843	2.925828	2.925879	2.925931	2.925982	2.926034	51
844	2.926342	2.926394	2.926445	2.926497	2.926548	51
845	2.926857	2.926908	2.926959	2.927011	2.927062	51
846	2.927370	2.927422	2.927473	2.927524	2.927576	51
847	2.927883	2.927935	2.927986	2.928037	2.928088	51
848	2.928396	2.928447	2.928498	2.928549	2.928601	51
849	2.928908	2.928959	2.929010	2.929061	2.929112	51
850	2.929419	2.929470	2.929521	2.929572	2.929623	51
851	2.929930	2.929981	2.930032	2.930083	2.930134	51
852	2.930440	2.930491	2.930541	2.930592	2.930643	51
853	2.930949	2.931000	2.931051	2.931102	2.931153	51
854	2.931458	2.931509	2.931560	2.931610	2.931661	51
855	2.931966	2.932017	2.932068	2.932118	2.932169	51
856	2.932474	2.932524	2.932575	2.932626	2.932677	51
857	2.932981	2.933031	2.933082	2.933133	2.933183	51
858	2.933487	2.933538	2.933588	2.933639	2.933690	51
859	2.933993	2.934044	2.934094	2.934145	2.934195	51
860	2.934498	2.934549	2.934599	2.934650	2.934700	50
861	2.935003	2.935054	2.935104	2.935154	2.935205	50
862	2.935507	2.935558	2.935608	2.935658	2.935709	50
863	2.936011	2.936061	2.936111	2.936162	2.936212	50
864	2.936514	2.936564	2.936614	2.936664	2.936715	50
865	2.937016	2.937066	2.937116	2.937167	2.937217	50
866	2.937518	2.937568	2.937618	2.937668	2.937718	50
867	2.938019	2.938069	2.938119	2.938169	2.938219	50
868	2.938520	2.938570	2.938620	2.938670	2.938720	50
869	2.939020	2.939070	2.939120	2.939170	2.939220	50
870	2.939519	2.939569	2.939619	2.939669	2.939719	50
871	2.940018	2.940068	2.940118	2.940168	2.940218	50
872	2.940516	2.940566	2.940616	2.940666	2.940716	50
873	2.941014	2.941064	2.941114	2.941163	2.941213	50

Num	5	6	7	8	9	Diff.
831	2.919862	2.919914	2.919967	2.920019	2.920071	52
832	2.920384	2.920436	2.920489	2.920541	2.920593	52
833	2.920906	2.920958	2.921010	2.921062	2.921114	52
834	2.921426	2.921478	2.921530	2.921582	2.921634	52
835	2.921946	2.921998	2.922050	2.922102	2.922154	52
836	2.922466	2.922518	2.922570	2.922622	2.922674	52
837	2.922985	2.923037	2.923088	2.923140	2.923192	52
838	2.923503	2.923555	2.923607	2.923658	2.923710	52
839	2.924021	2.924072	2.924124	2.924176	2.924228	52
840	2.924538	2.924589	2.924641	2.924693	2.924744	52
841	2.925054	2.925106	2.925157	2.925209	2.925260	52
842	2.925570	2.925621	2.925673	2.925724	2.925776	52
843	2.926085	2.926137	2.926188	2.926239	2.926291	52
844	2.926600	2.926651	2.926702	2.926754	2.926805	51
845	2.927114	2.927165	2.927216	2.927268	2.927319	51
846	2.927627	2.927678	2.927730	2.927781	2.927832	51
847	2.928140	2.928191	2.928242	2.928293	2.928345	51
848	2.928652	2.928703	2.928754	2.928805	2.928856	51
849	2.929163	2.929214	2.929266	2.929317	2.929368	51
850	2.929674	2.929725	2.929776	2.929827	2.929878	51
851	2.930185	2.930236	2.930287	2.930338	2.930389	51
852	2.930694	2.930745	2.930796	2.930847	2.930898	51
853	2.931203	2.931254	2.931305	2.931356	2.931407	51
854	2.931712	2.931763	2.931814	2.931864	2.931915	51
855	2.932220	2.932271	2.932321	2.932372	2.932423	51
856	2.932727	2.932778	2.932829	2.932879	2.932930	51
857	2.933234	2.933285	2.933335	2.933386	2.933437	51
858	2.933740	2.933791	2.933841	2.933892	2.933943	51
859	2.934246	2.934296	2.934347	2.934397	2.934448	51
860	2.934751	2.934801	2.934852	2.934902	2.934953	50
861	2.935255	2.935306	2.935356	2.935406	2.935457	50
862	2.935759	2.935809	2.935860	2.935910	2.935960	50
863	2.936262	2.936313	2.936363	2.936413	2.936463	50
864	2.936765	2.936815	2.936865	2.936916	2.936966	50
865	2.937267	2.937317	2.937367	2.937418	2.937468	50
866	2.937769	2.937819	2.937869	2.937919	2.937969	50
867	2.938269	2.938319	2.938370	2.938420	2.938470	50
868	2.938770	2.938820	2.938870	2.938920	2.938970	50
869	2.939270	2.939319	2.939369	2.939419	2.939469	50
870	2.939769	2.939819	2.939868	2.939918	2.939968	50
871	2.940267	2.940317	2.940367	2.940417	2.940467	50
872	2.940765	2.940815	2.940865	2.940915	2.940965	50
873	2.941263	2.941313	2.941362	2.941412	2.941462	50

Num	0	1	2	3	4	Diff.
745	2.872156	2.872215	2.872273	2.872331	2.872389	58
746	2.872739	2.872797	2.872855	2.872913	2.872972	58
747	2.873321	2.873379	2.873437	2.873495	2.873553	58
748	2.873902	2.873960	2.874018	2.874076	2.874134	58
749	2.874482	2.874540	2.874598	2.874656	2.874714	58
750	2.875061	2.875119	2.875177	2.875235	2.875293	58
751	2.875640	2.875698	2.875756	2.875815	2.875871	58
752	2.876218	2.876276	2.876333	2.876391	2.876449	58
753	2.876795	2.876853	2.876910	2.876968	2.877026	58
754	2.877371	2.877429	2.877486	2.877544	2.877602	58
755	2.877947	2.878004	2.878062	2.878119	2.878177	57
756	2.878522	2.878579	2.878637	2.878694	2.878751	57
757	2.879096	2.879153	2.879211	2.879268	2.879325	57
758	2.879669	2.879726	2.879784	2.879841	2.879898	57
759	2.880242	2.880299	2.880356	2.880413	2.880471	57
760	2.880814	2.880871	2.880928	2.880985	2.881042	57
761	2.881385	2.881442	2.881499	2.881556	2.881613	57
762	2.881955	2.882012	2.882069	2.882126	2.882183	57
763	2.882524	2.882581	2.882638	2.882695	2.882752	57
764	2.883093	2.883150	2.883207	2.883264	2.883321	57
765	2.883661	2.883718	2.883775	2.883832	2.883889	57
766	2.884229	2.884285	2.884342	2.884399	2.884455	57
767	2.884795	2.884852	2.884909	2.884965	2.885022	57
768	2.885361	2.885418	2.885474	2.885531	2.885587	57
769	2.885926	2.885983	2.886039	2.886096	2.886152	56
770	2.886491	2.886547	2.886603	2.886660	2.886716	56
771	2.887054	2.887111	2.887167	2.887223	2.887280	56
772	2.887617	2.887673	2.887730	2.887786	2.887842	56
773	2.888179	2.888236	2.888292	2.888348	2.888404	56
774	2.888741	2.888797	2.888853	2.888909	2.888965	56
775	2.889302	2.889358	2.889414	2.889470	2.889526	56
776	2.889862	2.889918	2.889974	2.890030	2.890089	56
777	2.890421	2.890477	2.890533	2.890586	2.890644	56
778	2.890980	2.891035	2.891091	2.891147	2.891203	56
779	2.891537	2.891593	2.891649	2.891705	2.891760	56
780	2.892095	2.892150	2.892206	2.892262	2.892317	56
781	2.892651	2.892707	2.892762	2.892818	2.892873	56
782	2.893207	2.893262	2.893318	2.893373	2.893429	56
783	2.893762	2.893817	2.893873	2.893928	2.893984	55
784	2.894316	2.894371	2.894427	2.894482	2.894538	55
785	2.894870	2.894925	2.894980	2.895036	2.895091	55
786	2.895422	2.895478	2.895533	2.895588	2.895643	55
787	2.895975	2.896030	2.896085	2.896140	2.896195	55

Num	5	6	7	8	9	Diff.
745	2.872448	2.872506	2.872564	2.872622	2.872681	58
746	2.873030	2.873088	2.873146	2.873204	2.873262	58
747	2.873611	2.873669	2.873727	2.873785	2.873843	58
748	2.874192	2.874250	2.874308	2.874366	2.874424	58
749	2.874772	2.874830	2.874887	2.874945	2.875003	58
750	2.875351	2.875409	2.875466	2.875524	2.875582	58
751	2.875929	2.875987	2.876045	2.876102	2.876160	58
752	2.876506	2.876564	2.876622	2.876680	2.876737	58
753	2.877083	2.877141	2.877198	2.877256	2.877314	58
754	2.877659	2.877717	2.877774	2.877832	2.877889	58
755	2.878234	2.878292	2.878349	2.878407	2.878464	57
756	2.878809	2.878866	2.878924	2.878981	2.879038	57
757	2.879383	2.879440	2.879497	2.879555	2.879612	57
758	2.879956	2.880013	2.880070	2.880127	2.880185	57
759	2.880528	2.880585	2.880642	2.880699	2.880756	57
760	2.881099	2.881156	2.881213	2.881270	2.881328	57
761	2.881670	2.881727	2.881784	2.881841	2.881898	57
762	2.882240	2.882297	2.882354	2.882411	2.882468	57
763	2.882809	2.882866	2.882923	2.882980	2.883036	57
764	2.883377	2.883434	2.883491	2.883548	2.883605	57
765	2.883945	2.884002	2.884059	2.884115	2.884172	57
766	2.884512	2.884569	2.884625	2.884682	2.884739	57
767	2.885078	2.885135	2.885191	2.885248	2.885305	57
768	2.885644	2.885700	2.885757	2.885813	2.885870	57
769	2.886209	2.886265	2.886321	2.886378	2.886434	56
770	2.886773	2.886829	2.886885	2.886942	2.886998	56
771	2.887336	2.887392	2.887448	2.887505	2.887561	56
772	2.887898	2.887955	2.888011	2.888068	2.888123	56
773	2.888460	2.888516	2.888573	2.888629	2.888685	56
774	2.889021	2.889077	2.889134	2.889190	2.889246	56
775	2.889582	2.889638	2.889694	2.889750	2.889806	56
776	2.890141	2.890197	2.890253	2.890309	2.890365	56
777	2.890700	2.890756	2.890812	2.890868	2.890924	56
778	2.891259	2.891314	2.891370	2.891426	2.891482	56
779	2.891816	2.891872	2.891927	2.891983	2.892039	56
780	2.892373	2.892428	2.892484	2.892540	2.892595	56
781	2.892929	2.892985	2.893040	2.893096	2.893151	56
782	2.893484	2.893540	2.893595	2.893651	2.893706	56
783	2.894039	2.894094	2.894150	2.894205	2.894261	55
784	2.894593	2.894648	2.894704	2.894759	2.894814	55
785	2.895146	2.895201	2.895257	2.895312	2.895367	55
786	2.895699	2.895754	2.895809	2.895864	2.895919	55
787	2.896251	2.896306	2.896361	2.896416	2.896471	55

Num	0	1	2	3	4	Diff
917	2.962369	2.962417	2.962464	2.962511	2.962559	47
918	2.962843	2.962890	2.962937	2.962985	2.963032	47
919	2.963315	2.963363	2.963410	2.963457	2.963504	47
920	2.963788	2.963835	2.963882	2.963929	2.963977	47
921	2.964260	2.964307	2.964354	2.964401	2.964448	47
922	2.964731	2.964778	2.964825	2.964872	2.964919	47
923	2.965202	2.965249	2.965296	2.965343	2.965390	47
924	2.965672	2.965719	2.965766	2.965813	2.965860	47
925	2.966142	2.966189	2.966236	2.966283	2.966329	47
926	2.966611	2.966658	2.966705	2.966752	2.966798	47
927	2.967080	2.967127	2.967173	2.967220	2.967267	47
928	2.967548	2.967595	2.967642	2.967688	2.967735	47
929	2.968016	2,968062	2,968109	2.968156	2.968203	47
930	2.968483	2.968530	2.968576	2.968623	2.968670	47
931	2.968950	2.968996	2,969043	2.969090	2.969136	47
932	2.969416	2.969462	2.969509	2.969556	2.969602	47
933	2.969882	2.969928	2.969975	2.970021	2.970068	47
934	2.970347	2.970393	2.970440	2.970486	2.970533	46
935	2 970812	2.970858	2 970904	2.970951	2.970997	46
936	2.971276	2.971322	2.971369	2.971415	2.971461	46
937	2.971740	2.971786	2.971832	2.971879	2 971925	46
938	2.972203	2.972249	2.972295	2.972342	2.972388	46
939	2.972666	2.972712	2.972758	2.972804	2.972851	46
940	2.973128	2.973174	2.973220	2.973266	2.973313	46
941	2.973590	2.973636	2.973682	2.973728	2.973774	46
942	2.974051	2.974097	2.974143	2.974189	2.974235	46
943	2.974512	2.974558	2 974604	2.974650	2.974696	46
944	2.974972	2 975018	2.975064	2.975110	2.975156	46
945	2 975432	2.975478	2.975524	2.975570	2.975616	46
946	2 975891	2.975937	2.975983	2.976029	2 976075	46
947	2.976350	2.976396	2.976442	2 976487	2.976533	46
948	2 976808	2.976854	2 976900	2.976946	2.976991	46
949	2 977266	2.977312	2.977358	2.977403	2.977449	46
950	2.977724	2.977769	2.977815	2.977861	2 977906	46
951	2.978180	2 978226	2.978272	2.978317	2.978363	46
952	2 978637	2.978683	2.978728	2 978774	2.978819	46
953	2.979093	2.979138	2.979184	2.979230	2.979275	46
954	2.979548	2.979594	2 979639	2.979685	2.979730	46
955	2 980003	2.980049	2.980094	2.980140	2 980185	45
956	2.980458	2 980503	2.980549	2 980594	2 980640	45
957	2.980912	2.980957	2.981003	2.981048	2.981093	45
958	2.981365	2.981411	2.981456	2.981501	2.981547	45
959	2.981819	2.981864	2.981909	2.981954	2 982000	45

Num	5	6	7	8	9	Diff.
917	2.962606	2.962653	2.962701	2.962748	2.962795	47
918	2.963079	2.963126	2.963174	2.963221	2.963268	47
919	2.963552	2.963599	2.963646	2.963693	2.963741	47
920	2.964024	2.964071	2.964118	2.964165	2.964212	47
921	2.964495	2.964542	2.964590	2.964637	2.964684	47
922	2.964966	2.965013	2.965060	2.965108	2.965155	47
923	2.965437	2.965484	2.995531	2.965578	2.965625	47
924	2.965907	2.965954	2.966001	2.966048	2.966095	47
925	2 966376	2.966423	2.966470	2.966517	2.966564	47
926	2.966845	2.966892	2.966939	2.966986	2.967033	47
927	2.967314	2.967361	2.967408	2.967454	2.967501	47
928	2.967782	2.967829	2.967875	2.967922	2.967969	47
929	2.968249	2.968296	2.968343	2.968389	2.968436	47
930	2.968716	2.968763	2.968810	2.968856	2.968903	47
931	2.969183	2.969229	2.969276	2.969323	2.969369	47
932	2.969649	2.969695	2.969742	2.969788	2.969835	47
933	2.970114	2.970161	2.970207	2.970254	2.970300	47
934	2.970579	2.970626	2.970672	2.970719	2.970765	47
935	2.971044	2.971090	2.971137	2.971183	2.971229	46
936	2.971508	2.971554	2.971600	2.971647	2.971693	46
937	2.971971	2.972018	2.972064	2.972110	2.972156	46
938	2.972434	2.972480	2 972527	2.972573	2.972619	46
939	2.972897	2.972943	2.972989	2.973035	2.973082	46
940	2.973359	2.973405	2.973451	2.973497	2.973543	46
941	2.973820	2.973866	2.973913	2 973959	2.974005	46
942	2.974281	2.974327	2.974373	2.974420	2.974466	46
943	2.974742	2.974788	2.974834	2.974880	2.974926	46
944	2.975202	2.975248	2.975294	2.975340	2.975386	46
945	2.975661	2.975707	2.975753	2.975799	2.975845	46
946	2.976121	2.976166	2.976212	2.976258	2 976304	46
947	2.976579	2.976625	2.976671	2.976717	2.976762	46
948	2.977037	2.977083	2.977129	2.977175	2.977220	46
949	2.977495	2.977541	2.977586	2.977632	2.977678	46
950	2.977952	2.977998	2.978043	2.978089	2.978135	46
951	2.978409	2.978454	2.978500	2.978546	2.978591	46
952	2.978865	2.978911	2.978956	2.979002	2.979047	46
953	2.979321	2.979366	2.979412	2.979457	2.979503	46
954	2.979776	2.979821	2.979867	2.979912	2.979958	46
955	2.980231	2.980276	2.980322	2.980367	2.980412	45
956	2.980685	2.980730	2 980776	2 980821	2.980867	45
957	2.981139	2.981184	2.981229	2.981275	2.981320	45
958	2.981592	2.981637	2.981683	2.981728	2.981773	45
959	2.982045	2.982090	2.982135	2.982181	2.982226	45

Nam	0	1	2	3	4	Diff
960	2.982271	2.982316	2.982362	2.982407	2.982452	45
961	2.982723	2.982769	2.982814	2.982859	2.982904	45
962	2.983175	2.983220	2.983265	2.983310	2.983356	45
963	2.983626	2.983671	2.983716	2.983762	2.983807	45
964	2.984077	2.984122	2.984167	2.984212	2.984257	45
965	2.984527	2.984572	2.984617	2.984662	2.984707	45
966	2.984977	2.985022	2.985067	2.985112	2.985157	45
967	2.985426	2.985471	2.985516	2.985561	2.985606	45
968	2.985875	2.985920	2.985965	2 986010	2.986055	45
969	2.986324	2.986369	2.986413	2.986458	2.986503	45
970	2.986772	2.986816	2.986861	2.986906	2.986951	45
971	2.987219	2.987264	2.987309	2.987353	2.987398	45
972	2.987666	2.987711	2.987756	2.987800	2.987845	45
973	2.988113	2.988157	2.988202	2.988247	2.988291	45
974	2.988559	2.988603	2,988648	2.988693	2.988737	45
975	2.989005	2.989049	2.989094	2.989138	2.989183	45
976	2.989450	2.989494	2.989539	2.989583	2.989628	44
977	2.989895	2.989939	2.989983	2.990028	2.990072	44
978	2.990339	2.990383	2 990428	2.990472	2.990516	44
979	2.990783	2.990827	2.990871	2.990916	2.990960	44
980	2.991226	2.991270	2.991315	2.991359	2.991403	44
981	2.991669	2.991713	2.991757	2.991802	2.991846	44
982	2.992111	2.992156	2.992200	2.992244	2.992288	44
983	2.992553	2.992598	2.992642	2.992686	2.992730	44
984	2.992995	2.993039	2.993083	2.993127	2.993172	44
985	2.993436	2.993480	2.993524	2.993568	2.993613	44
986	2.993877	2.993921	2 993965	2.994009	2.994053	44
987	2.994317	2.994361	2.994405	2.994449	2.994493	44
988	2 994757	2.994801	2.994845	2.994889	2.994933	44
989	2 995196	2.995240	2.995284	2.995328	2 995372	44
990	2.995635	2.995679	2.995723	2 995767	2.995811	44
991	2 996074	2.996117	2 996161	2.996205	2.996249	44
992	2.996512	2.996555	2.996599	2.996643	2.996687	44
993	2.996949	2 996993	2.997037	2.997080	2.997124	44
994	2.997386	2.997430	2.997474	2.997517	2.997561	44
995	2 997823	2.997867	2.997910	2.997954	2.997998	44
996	2.998259	2.998303	2 998346	2.998390	2.998434	44
997	2.998695	2.998739	2.998782	2.998826	2.998869	44
998	2 999130	2 999174	2.999218	2.999261	2.999305	44
999	2.999565	2.999609	2.999652	2 999696	2 999739	43

Num	5	6	7	8	9	Diff
960	2.982497	2.982543	2.982588	2.982633	2.982678	45
961	2.982949	2.982994	2.983040	2.983085	2.983130	45
962	2.983401	2.983446	2.983491	2.983536	2.983581	45
963	2.983852	2.983897	2.983942	2.983987	2.984032	45
964	2.984302	2.984347	2.984392	2.984437	2.984482	45
965	2.984752	2.984797	2.984842	2.984887	2.984932	45
966	2.985202	2.985247	2.985292	2.985337	2.985382	45
967	2.985651	2.985696	2.985741	2.985786	2.985830	45
968	2.986100	2.986144	2.986189	2.986234	2.986279	45
969	2.986548	2.986593	2.986637	2.986682	2.986727	45
970	2.986995	2.987040	2.987085	2.987130	2.987174	45
971	2.987443	2.987487	2.987532	2.987577	2.987622	45
972	2.987890	2.987934	2.987979	2.988024	2.988068	45
973	2.988336	2.988381	2.988425	2.988470	2.988514	45
974	2.988782	2.988826	2.988871	2.988915	2.988960	45
975	2.989227	2.989272	2.989316	2.989361	2.989405	45
976	2.989672	2.989717	2.989761	2.989806	2.989850	44
977	2.990117	2.990161	2.990206	2.990250	2.990294	44
978	2.990561	2.990605	2.990650	2.990694	2.990738	44
979	2.991004	2.991049	2.991093	2.991137	2.991182	44
980	2.991448	2.991492	2.991536	2.991580	2.991625	44
981	2.991890	2.991934	2.991979	2.992023	2.992067	44
982	2.992333	2.992377	2.992421	2.992465	2.992509	44
983	2.992774	2.992818	2.992863	2.992907	2.992951	44
984	2.993216	2.993260	2.993304	2.993348	2.993392	44
985	2.993657	2.993701	2.993745	2.993789	2.993833	44
986	2.994097	2.994141	2.994185	2.994229	2.994273	44
987	2.994537	2.994581	2.994625	2.994669	2.994713	44
988	2.994977	2.995021	2.995064	2.995108	2.995152	44
989	2.995416	2.995460	2.995504	2.995547	2.995591	44
990	2.995854	2.995898	2.995942	2.995986	2.996030	44
991	2.996293	2.996336	2.996380	2.996424	2.996468	44
992	2.996730	2.996774	2.996818	2.996862	2.996905	44
993	2.997168	2.997212	2.997255	2.997299	2.997343	44
994	2.997605	2.997648	2.997692	2.997736	2.997779	44
995	2.998041	2.998085	2.998128	2.998172	2.998216	44
996	2.998477	2.998521	2.998564	2.998608	2.998652	44
997	2.998913	2.998956	2.999000	2.999043	2.999087	44
998	2.999348	2.999392	2.999435	2.999478	2.999522	44
999	2.999783	2.999826	2.999870	2.999913	2.999957	43

0 Degree.

Minutes	Sine		Tangent		Secant		
0	0.000000	10.000000	0.000000	Infinite.	10.000000	Infinite	60
1	6.463726	9.999999	6.463726	13.536274	10.000000	13.536274	59
2	6.764756	9.999999	6.764756	13.235244	10.000000	13.235244	58
3	6.940847	9.999999	6.940847	13.059153	10.000000	13.059153	57
4	7.065786	9.999999	7.065786	12.934214	10.000000	13.934214	56
5	7.162696	9.999999	7.162696	12.837304	10.000000	12.837304	55
6	7.241877	9.999999	7.241878	12.758122	10.000001	12.758123	54
7	7.308824	9.999999	7.308825	12.691175	10.000001	12.691176	53
8	7.366816	9.999999	7.366817	12.633183	10.000001	12.633184	52
9	7.417968	9.999999	7.417970	12.582030	10.000001	12.582032	51
10	7.463725	9.999998	7.463727	12.536273	10.000002	12.536275	50
11	7.505118	9.999998	7.505120	12.494880	10.000002	12.494883	49
12	7.542907	9.999997	7.542909	12.457091	10.000003	12.457093	48
13	7.577668	9.999997	7.577671	12.422328	10.000003	12.422332	47
14	7.609853	9.999996	7.609857	12.390143	10.000004	12.390147	46
15	7.639816	9.999996	7.639820	12.360180	10.000004	11.360184	45
16	7.667844	9.999995	7.667849	12.332151	10.000005	12.332156	44
17	7.694173	9.999995	7.694179	12.305821	10.000005	12.305827	43
18	7.718997	9.999994	7.719003	12.280997	10.000006	12.281003	42
19	7.742478	9.999993	7.742484	12.257516	10.000007	12.257522	41
20	7.764754	9.999993	7.764761	12.235239	10.000007	12.235246	40
21	7.785943	9.999992	7.785951	12.214049	10.000008	12.214057	39
22	7.806146	9.999991	7.806155	12.193845	10.000009	12.193854	38
23	7.825451	9.999990	7.825460	12.174540	10.000010	12.174549	37
24	7.843934	9.999989	7.843944	12.156056	10.000011	12.156066	36
25	7.861662	9.999988	7.861674	12.138326	10.000012	12.138338	35
26	7.878695	9.999988	7.878708	12.121292	10.000012	12.121305	34
27	7.895085	9.999987	7.895099	12.104901	10.000013	12.104915	33
28	7.910879	9.999986	7.910894	12.089106	10.000014	12.089121	32
29	7.926119	9.999984	7.926134	12.073866	10.000016	12.073881	31
30	7.940842	9.999983	7.940858	12.059142	10.000017	12.059158	30
		Sine		Tangent		Secant	Minutes

0 Degree.

Minutes	Sine		Tangent		Secant		
30	7.940842	9.999984	7.940858	12.059142	10.000016	12.059158	30
31	7.955082	9.999982	7.955100	12.044900	10.000018	12.044918	29
32	7.968870	9.999981	7.968889	12.031111	10.000019	12.031130	28
33	7.982233	9.999980	7.982253	12.017747	10.000020	12.017767	27
34	7.995198	9.999979	7.995219	12.004781	10.000021	12.004802	26
35	8.007787	9.999977	8.007809	11.992191	10.000023	11.992213	25
36	8.020021	9.999976	8.020045	11.979955	10.000024	11.979979	24
37	8.031919	9.999975	8.031945	11.968055	10.000025	11.968081	23
38	8.043501	9.999974	8.043527	11.956473	10.000026	11.956499	22
39	8.054781	9.999972	8.054809	11.945191	10.000028	11.945219	21
40	8.065776	9.999971	8.065806	11.934194	10.000029	11.934224	20
41	8.076500	9.999969	8.076531	11.923469	10.000031	11.923500	19
42	8.086965	9.999968	8.086997	11.913003	10.000032	11.913035	18
43	8.097183	9.999966	8.097217	11.902783	10.000034	11.902817	17
44	8.107167	9.999964	8.107202	11.892798	10.000036	11.892833	16
45	8.116926	9.999963	8.116963	11.883037	10.000037	11.883074	15
46	8.126471	9.999961	8.126510	11.873490	10.000039	11.873529	14
47	8.135819	9.999959	8.135851	11.864149	10.000041	11.864190	13
48	8.144953	9.999958	8.144996	11.855004	10.000042	11.855047	12
49	8.153908	9.999956	8.153952	11.846048	10.000044	11.846092	11
50	8.162681	9.999954	8.162727	11.837273	10.000046	11.837319	10
51	8.171280	9.999952	8.171328	11.828672	10.000048	11.828720	9
52	8.179713	9.999950	8.179763	11.820237	10.000050	11.820287	8
53	8.187985	9.999948	8.188036	11.811964	10.000052	11.812015	7
54	8.196102	9.999946	8.196156	11.803844	10.000054	11.803898	6
55	8.204070	9.999944	8.204126	11.795874	10.000056	11.795930	5
56	8.211895	9.999942	8.211953	11.788047	10.000058	11.788105	4
57	8.219581	9.999940	8.219641	11.780359	10.000060	11.780419	3
58	8.227134	9.999938	8.227195	11.772805	10.000062	11.772866	2
59	8.234557	9.999936	8.234621	11.765379	10.000064	11.765443	1
60	8.241855	9.999934	8.241922	11.758078	10.000066	11.758145	0
		Sine		Tangent		Secant	Minutes

89 Degrees.

1 Degree.

Minutes	Sine		Tangent		Secant		
0	8.241855	9.999934	8.241921	11.758079	10.000066	11.758145	60
1	8.249033	9.999932	8.249102	11.750898	10.000068	11.750967	59
2	8.256094	9.999929	8.256165	11.743835	10.000071	11.743906	58
3	8.263042	9.999927	8.263115	11.736885	10.000073	11.736958	57
4	8.269881	9.999925	8.269956	11.730044	10.000075	11 730119	56
5	8.276614	9.999922	8.276691	11.723309	10.000078	11.723386	55
6	8.283243	9.999920	8.283323	11.716677	10.000080	11.716757	54
7	8.289773	9.999917	8.289856	11.710144	10.000082	11.710227	53
8	8 296207	9.999915	8.296292	11.703708	10.000085	11.703793	52
9	8.302546	9 999912	8.302633	11.697367	10.000087	11 697454	51
10	8.308794	9.999910	8.308884	11.691116	10 000090	11.691206	50
11	8.314954	9.999907	8.315045	11.684954	10.000093	11.685046	49
12	8.321027	9.999905	8.321122	11.678878	10.000095	11.678973	48
13	8.327016	9 999902	8.327114	11.672886	10.000098	11.672984	47
14	8.332924	9.999899	8.333025	11.666975	10.000101	11.667076	46
15	8.338753	9.999897	8.338856	11.661144	10.000103	11.661247	45
16	8.344504	9.999894	8.344610	11.655389	10 000106	11.655496	44
17	8.350180	9.999891	8.350289	11.649710	10.000109	11 649819	43
18	8.355783	9.999888	8.355895	11 644105	10.000112	11.644216	42
19	8.361315	9.999885	8.361430	11.638570	10 000115	11.638685	41
20	8.366777	9 999882	8.366894	11.633105	10.000118	11.633223	40
21	8.372171	9.999879	8.372291	11.627708	10.000121	11.627829	39
22	8.377499	9 999876	8.377622	11.622378	10.000124	11.622501	38
23	8.382762	9.999873	8.382889	11.617111	10.000127	11.617238	37
24	8.387962	9.999870	8.388092	11,611908	10.000130	11.612038	36
25	8.393101	9.999867	8.393234	11.606766	10.000133	11.606899	35
26	8.398179	9.999864	8.398315	11.601685	10.000136	11.601821	34
27	8.403199	9 999861	8.403338	11.596662	10 000139	11.596801	33
28	8.408161	9.999858	8.408304	11.591696	10.000142	11.591839	32
29	8.413068	9 999854	8.413213	11.586787	10.000146	11.586932	31
30	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081	30
		Sine		Tangent		Secant	Minutes

88 Degrees.

1 Degree.

Minutes	Sine		Tangent		Secant		
30	8.417919	9.999851	8.418068	11.581932	10.000149	11.582081	30
31	8.422717	9.999848	8.422869	11.577131	10.000152	11.577283	29
32	8.427462	9.999844	8.427618	11.572382	10.000156	11.572538	28
33	8.432156	9.999841	8.432315	11.567685	10.000159	11.567844	27
34	8.436800	9.999838	8.436962	11.563038	10.000162	11.563200	26
35	8.441394	9.999834	8.441560	11.558440	10.000166	11.558606	25
36	8.445941	9.999831	8.446110	11.553890	10.000169	11.554059	24
37	8.450440	9.999827	8.450613	11.549387	10.000173	11.549569	23
38	8.454893	9.999823	8.455070	11.544930	10.000177	11.545107	22
39	8.459301	9.999820	8.459481	11.540519	10.000180	11.540699	21
40	8.463665	9.999816	8.463849	11.536151	10.000184	11.536335	20
41	8.467985	9.999812	8.468172	11.531827	10.000188	11.532015	19
42	8.472263	9.999809	8.472454	11.527546	10.000191	11.527737	18
43	8.476498	9.999805	8.476693	11.523307	10.000195	11.523502	17
44	8.480693	9.999801	8.480892	11.519108	10.000199	11.519307	16
45	8.484848	9.999797	8.485051	11.514949	10.000203	11.515152	15
46	8.488963	9.999793	8.489170	11.510830	10.000207	11.511037	14
47	8.493040	9.999790	8.493250	11.506750	10.000210	11.506960	13
48	8.497078	9.999786	8.497293	11.502707	10.000214	11.502922	12
49	8.501080	9.999782	8.501298	11.498702	10.000218	11.498920	11
50	8.505045	9.999778	8.505267	11.494733	10.000222	11.494955	10
51	8.508974	9.999774	8.509200	11.490800	10.000226	11.491026	9
52	8.512867	9.999769	8.513098	11.486902	10.000231	11.487133	8
53	8.516726	9.999765	8.516961	11.483039	10.000235	11.483274	7
54	8.520551	9.999761	8.520790	11.479210	10.000239	11.479449	6
55	8.524343	9.999757	8.524586	11.475414	10.000243	11.475657	5
56	8.528102	9.999753	8.528349	11.471651	10.000247	11.471898	4
57	8.531828	9.999748	8.532080	11.467920	10.000252	11.468172	3
58	8.535523	9.999744	8.535779	11.464221	10.000256	11.464477	2
59	8.539186	9.999740	8.539447	11.460553	10.000260	11.460814	1
60	8.542819	9.999735	8.543085	11.456916	10.000265	11.457181	0
		Sine		Tangent		Secant	Minutes

2 Degrees.

Minutes	Sine		Tangent		Secant		
0	8.542819	9.999735	8.543084	11.456916	10.000265	11.457181	60
1	8.546422	9.999731	8.546691	11.453309	10.000269	11.453578	59
2	8.549995	9 999727	8.550268	11.449732	10.000273	11.450005	58
3	8.553539	9 999722	8.553817	11.446183	10.000278	11.446461	57
4	8.557054	9.999717	8,557336	11.442664	10 000283	11.442946	56
5	8.560540	9.999713	8.560828	11.439172	10.000287	11.439460	55
6	8.563999	9.999708	8.564291	11.435709	10.000292	11.436001	54
7	8.567431	9.999704	8.567727	11.432273	10.000296	11 432569	53
8	8 570836	9.999699	8.571137	11.428863	10.000301	11.429164	52
9	8.574214	9.999694	8,574520	11.425480	10 000306	11.425786	51
10	8.577566	9.999689	8.577877	11.422123	10.000311	11.422434	50
11	8.580892	9.999685	8.581208	11.418792	10.000315	11.419108	49
12	8.584193	9.999680	8.584514	11.415486	10.000320	11.415807	48
13	8.587469	9 999675	8.587795	11.412205	10.000325	11.412531	47
14	8.590721	9.999670	8.591051	11.408949	10.000330	11 409279	46
15	8.593948	9.999665	8.594283	11.405717	10.000335	11.406052	45
16	8.597152	9.999660	8.597492	11.402508	10.000340	11.402848	44
17	8.600332	9 999655	8.600677	11.399323	10.000345	11.399668	43
18	8.603489	9.999650	8.603839	11.396161	10.000350	11.396511	42
19	8.606623	9.999645	8.606978	11.393022	10.000355	11.393377	41
20	8.609734	9.999640	8.610094	11.389906	10.000360	11.390266	40
21	8.612823	9.999635	8.613189	11.386811	10.000365	11.387177	39
22	8.615891	9.999629	8.616262	11.383738	10.000371	11.384109	38
23	8.618937	9.999624	8.619313	11.380687	10.000376	11.381063	37
24	8.621962	9.999619	8.622343	11.377657	10.000381	11.378038	36
25	8.624965	9.999614	8.625352	11.374648	10.000386	11.375035	35
26	8.627948	9.999608	8.628340	11.371660	10.000392	11.372052	34
27	8.630911	9.999603	8.631308	11.368692	10.000397	11.369089	33
28	8.633854	9.999597	8.634256	11.365744	10.000403	11.366146	32
29	8 636776	9.999592	8.637185	11.362815	10.000408	11.363224	31
30	8.639680	9.999587	8.640093	11.359907	10.000413	11.360320	30
		Siue		Tangent		Secant	Minutes

87 Degrees.

2 Degrees.

Minutes	Sine		Tangent		Secant		
30	8.639680	9.999586	8.640093	11.359907	10 000414	11.360320	30
31	8.642563	9.999581	8.642982	11.357018	10.000419	11.357437	29
32	8 645428	9.999575	8.645853	11.354147	10.000425	11.354572	28
33	8.648274	9.999570	8.648704	11.351296	10.000430	11.351726	27
34	8.651102	9.999564	8.651538	11.348462	10.000436	11.348898	26
35	8.653911	9.999558	8.654352	11.345648	10.000442	11.346089	25
36	8.656702	9.999553	8.657149	11.342851	10.000447	11.343298	24
37	8.659475	9.999547	8.659928	11.340072	10.000453	11.340525	23
38	8.662230	9.999541	8.662689	11.337311	10.000459	11.337770	22
39	8.664968	9.999535	8.665433	11.334567	10.000465	11.335032	21
40	8.667689	9.999529	8.668160	11.331840	10.000471	11.332311	20
41	8.670393	9.999524	8.670870	11.329130	10.000476	11.329607	19
42	8.673080	9.999518	8.673563	11.326437	10.000482	11.326920	18
43	8 675751	9.999512	8.676239	11.323761	10.000488	11.324249	17
44	8.678405	9.999506	8.678900	11.321100	10.000494	11.321595	16
45	8.681043	9.999500	8.681544	11.318456	10.000500	11.318957	15
46	8.683665	9.999494	8.684172	11.315828	10.000506	11.316335	14
47	8.686272	9.999487	8.686784	11.313216	10.000513	11.313728	13
48	8.688863	9.999481	8.689381	11.310618	10.000519	11.311137	12
49	8 691438	9.999475	8.691963	11.308037	10.000525	11,308562	11
50	8.693998	9.999469	8.694529	11.305471	10.000531	11.306002	10
51	8.696543	9.999462	8.697081	11.302919	10.000538	11.303457	9
52	8.699073	9.999456	8 699617	11.300383	10.000544	11,300927	8
53	8.701589	9.999450	8.702139	11.297861	10.000550	11.298411	7
54	8.704090	9.999444	8.704646	11.295354	10.000556	11.295910	6
55	8.706577	9.999437	8.707139	11.292861	10.000563	11.293423	5
56	8.709049	9.999431	8.709619	11.290381	10.000569	11.290951	4
57	8.711508	9,999424	8.712083	11.287917	10.000576	11.288492	3
58	8.713952	9.999418	8.714535	11.285465	10.000582	11.286048	2
59	8.716383	9.999411	8.716972	11.283028	10.000589	11.283617	1
60	8 718800	9.999404	8.719396	11.280604	10.000596	11.281200	0
		Sine		Tangent		Secant	Minutes

87 Degrees.

3 Degrees.

Minutes	Sine		Tangent		Secant		
0	8.718800	9.999404	8.719396	11.280604	10.000596	11.281200	60
1	8.721204	9.999398	8.721806	11.278194	10.000602	11.278796	59
2	8.723595	9.999391	8.724203	11.275797	10.000609	11.276405	58
3	8.725972	9.999384	8.726588	11.273412	10.000616	11.274028	57
4	8.728337	9.999378	8.728959	11.271041	10.000622	11.271663	56
5	8.730688	9.999371	8.731317	11.268683	10.000629	11.269312	55
6	8.733027	9.999364	8.733663	11.266337	10.000636	11.266973	54
7	8.735353	9.999357	8.735996	11.264004	10.000643	11.264647	53
8	8.737668	9.999350	8.738317	11.261683	10.000650	11.262332	52
9	8.739969	9.999343	8.740626	11.259374	10.000657	11.260031	51
10	8.742259	9.999336	8.742922	11.257078	10.000663	11.257741	50
11	8.744536	9.999329	8.745207	11.254793	10.000671	11.255464	49
12	8.746802	9.999322	8.747479	11.252521	10.000678	11.253198	48
13	8.749055	9.999315	8.749740	11.250260	10.000685	11.250945	47
14	8.751297	9.999308	8.751989	11.248011	10.000692	11.248703	46
15	8.753528	9.999301	8.754227	11.245773	10.000699	11.246472	45
16	8.755747	9.999294	8.756453	11.243547	10.000706	11.244253	44
17	8.757955	9.999286	8.758668	11.241332	10.000714	11.242045	43
18	8.760151	9.999279	8.760872	11.239128	10.000721	11.239849	42
19	8.762337	9.999272	8.763065	11.236935	10.000728	11.237663	41
20	8.764511	9.999265	8.765246	11.234754	10.000735	11.235489	40
21	8.766675	9.999257	8.767418	11.232582	10.000743	11.233325	39
22	8.768827	9.999250	8.769578	11.230422	10.000750	11.231173	38
23	8.770970	9.999242	8.771727	11.228273	10.000758	11.229030	37
24	8.773101	9.999235	8.773866	11.226134	10.000765	11.226899	36
25	8.775223	9.999227	8.775995	11.224005	10.000773	11.224777	35
26	8.777333	9.999220	8.778114	11.221886	10.000780	11.222667	34
27	8.779434	9.999212	8.780222	11.219778	10.000788	11.220566	33
28	8.781524	9.999205	8.782320	11.217680	10.000795	11.218476	32
29	8.783605	9.999197	8.784408	11.215592	10.000803	11.216395	31
30	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325	30
		Sine		Tangent		Secant	Minutes

86 Degrees.

3 Degrees.

Minutes	Sine		Tangent		Secant		
30	8.785675	9.999189	8.786486	11.213514	10.000811	11.214325	30
31	8.787736	9.999181	8.788554	11.211446	10.000819	11.212264	29
32	8.789787	9.999174	8.790613	11.209387	10.000826	11.210213	28
33	8.791828	9.999166	8.792662	11.207338	10.000834	11.208172	27
34	8.763859	9.999158	8.794701	11.205299	10.000842	11.206141	26
35	8.795881	9.999150	8.796731	11.203269	10.000850	11.204119	25
36	8.797894	9.999142	8.798752	11.201248	10.000858	11.202106	24
37	8.799897	9.999134	8.800763	11.199237	10.000866	11.200103	23
38	8.801892	9.999126	8.802765	11.197235	10.000874	11.198108	22
39	8.803876	9.999118	8.804758	11.195242	10.000882	11,196124	21
40	8,805852	9.999110	8.806742	11.193258	10.000890	11.194148	20
41	8.807819	9.999102	8.808717	11.191283	10.000898	11.192181	19
42	8.809777	9.999094	8.810683	11.189317	10.000906	11.190223	18
43	8.811726	9.999086	8.812641	11.187359	10.000914	11.188274	17
44	8.813667	9.999077	8.814589	11.185411	10.000923	11.186333	16
45	8.815598	9.999069	8.816529	11.183471	10.000931	11.184402	15
46	8.817522	9.999061	8.818461	11.181539	10.000939	11.182478	14
47	8.819436	9.999052	8.820384	11.179616	10.000948	11.180564	13
48	8.821343	9.999044	8.822298	11.177702	10.000956	11.178657	12
49	8.823240	9 999036	8.824205	11.175795	10.000964	11.176760	11
50	8.825130	9.999027	8.826103	11.173897	10.000973	11.174870	10
51	8.827011	9.999019	8.827992	11.172008	10.000981	11.172989	9
52	8.828884	9.999010	8.829874	11.170126	10.000990	11.171116	8
53	8.830749	9.999002	8.831748	11.168252	10.000998	11.169251	7
54	8.832607	9.998993	8.833613	11.166387	10.001007	11.167393	6
55	8.834456	9.998984	8.835471	11.164529	10.001016	11.165544	5
56	8.836297	9.998976	8.837321	11.162679	10.001024	11.163703	4
57	8.838130	9.998967	8.839163	11.160837	10.001033	11.161870	3
58	8.839956	9.998958	8.840998	11.159002	10.001042	11.160044	2
59	8.841774	9.998950	8.842825	11.157175	10.001050	11.158226	1
60	8.843584	9.998941	8.844644	11.155356	10.001059	11.156416	0
		Sine		Tangent		Secant	Minutes

86 Degrees.

4 Degrees.

Minutes	Sine		Tangent		Secant		
0	8.843585	9.998941	8.844644	11.155356	10.001059	11.156415	60
1	8.845387	9.998932	8.846455	11.153545	10.001068	11.154613	59
2	8.847183	9.998923	8.848260	11.151740	10.001077	11.152817	58
3	8.848971	9.998914	8.850057	11.149943	10.001086	11.151029	57
4	8.850751	9.998905	8.851846	11.148154	10.001095	11.149249	56
5	8.852524	9.998896	8.853628	11,146372	10.001104	11.147476	55
6	8.854291	9.998887	8.855403	11.144597	10.001113	11.145709	54
7	8.856049	9.998878	8.857171	11.142829	10.001122	11.143951	53
8	8.857801	9.998869	8.858932	11.141068	10.001131	11.142199	52
9	8.859546	9.998860	8.860686	11.139314	10.001140	11.140454	51
10	8.861283	9.998851	8.862433	11.137567	10 001149	11.138717	50
11	8.863014	9.998841	8.864173	11.135827	10.001159	11.136986	49
12	8.864738	9.998832	8.865905	11.134095	10.001168	11.135262	48
13	8.866455	9.998823	8.867632	11,132368	10.001177	11.133545	47
14	8.868165	9.998813	8.869351	11.130649	10.001187	11.131835	46
15	8.869868	9.998804	8.871064	11.128936	10.001196	11.130132	45
16	8.871565	9.998795	8.872770	11.127230	10.001205	11.128435	44
17	8.873255	9.998785	8.874469	11.125531	10.001215	11.126745	43
18	8.874938	9.998776	8.876162	11.123838	10.001224	11.125062	42
19	8.876615	9.998766	8.877849	11.122151	10 001234	11.123385	41
20	8.878285	9.998757	8.879529	11.120471	10.001243	11.121715	40
21	8.879949	9.998747	8.881202	11.118798	10.001253	11.120051	39
22	8.881607	9.998737	8.882869	11.117131	10.001262	11.118393	38
23	8.883258	9.998728	8.884530	11.115470	10.001272	11.116742	37
24	8.884903	9.998718	8.886185	11.113815	10.001282	11.115097	36
25	8.886542	9.998708	8.887833	11.112167	10 001292	11.113458	35
26	8.888174	9.998699	8.889476	11.110524	10.001301	11.111826	34
27	8.889801	9.998689	8.891112	11.108888	10.001311	11.110199	33
28	8.891421	9.998679	8.892742	11.107258	10.001321	11.108579	32
29	8.893035	9.998669	8.894366	11.105634	10.001331	11.106965	31
30	8.894643	9 998659	8.895984	11.104016	10.001341	11.105357	30
		Sine		Tangent		Secant	Minutes

85 Degrees.

4 Degrees.

Minutes	Sine		Tangent		Secant		
30	8.894643	9.998659	8.895984	11.104016	10.001341	11.105357	30
31	8.896245	9.998649	8.897596	11.102404	10.001351	11.103754	29
32	8.897842	9.998639	8.899203	11.100797	10.001361	11.102158	28
33	8.899432	9.998629	8.900803	11.099197	10.001371	11.100568	27
34	8.901017	9.998619	8.902398	11.097602	10.001381	11.098983	26
35	8.902596	9.998609	8.903987	11.096013	10.001391	11.097404	25
36	8.904169	9.998599	8.905570	11.094430	10.001401	11.095831	24
37	8.905736	9.998589	8.907147	11.092853	10.001411	11.094264	23
38	8.907297	9.998578	8.908719	11.091281	10.001422	11.092703	22
39	8.908854	9.998568	8.910285	11.089715	10.001432	11.091146	21
40	8.910404	9.998558	8.911846	11.088154	10.001442	11.089596	20
41	8.911949	9.998548	8.913401	11.086599	10.001452	11.088051	19
42	8.913488	9.998537	8.914951	11.085049	10.001463	11.086512	18
43	8.915022	9.998527	8.916495	11.083505	10.001473	11.084978	17
44	8.916550	9.998516	8.918034	11.081966	10.001484	11.083450	16
45	8.918073	9.998506	8.919567	11.080432	10.001494	11.081927	15
46	8.919591	9.998495	8.921096	11.078904	10.001505	11.080409	14
47	8.921103	9.998485	8.922619	11.077381	10.001515	11.078897	13
48	8.922611	9.998474	8.924136	11.075864	10.001526	11.077389	12
49	8.924112	9.998464	8.925649	11.074351	10.001536	11.075888	11
50	8.925609	9.998453	8.927156	11.072844	10.001547	11.074391	10
51	8.927100	9.998442	8.928658	11.071342	10.001558	11.072900	9
52	8.928587	9.998431	8.930155	11.069845	10.001569	11.071413	8
53	8.930068	9.998421	8.931647	11.068353	10.001579	11.069932	7
54	8.931544	9.998410	8.933134	11.066866	10.001590	11.068456	6
55	8.933015	9.998399	8.934616	11.065384	10.001601	11.066985	5
56	8.934481	9.998388	8.936093	11.063907	10.001612	11.065519	4
57	8.935942	9.998377	8.937565	11.062435	10.001623	11.064058	3
58	8.937398	9.998366	8.939032	11.060968	10.001634	11.062602	2
59	8.938850	9.998355	8.940494	11.059506	10.001645	11.061150	1
60	8.940296	9.998344	8.941952	11.058048	10.001656	11.059704	0
		Sine		Tangent		Secant	Minutes

85 Degrees.

5 Degrees.

Minutes	Sine		Tangent		Secant		
0	8.940296	9.998344	8.941952	11.058048	10.001656	11.059704	60
1	8.941738	9.998333	8.943404	11.056596	10.001667	11.058262	59
2	8.943174	9.998322	8.944852	11.055148	10.001678	11.056820	58
3	8.944606	9.998311	8.946295	11.053705	10.001689	11.055394	57
4	8.946034	9.998300	8.947734	11.052266	10.001700	11.053966	56
5	8.947456	9.998289	8.949168	11,050832	10.001711	11.052544	55
6	8.948874	9.998277	8.950597	11.049403	10.001723	11.051126	54
7	8.950287	9.998266	8.952021	11.047979	10.001734	11.049713	53
8	8.951696	9.998255	8.953441	11.046559	10.001745	11.048304	52
9	8.953100	9.998243	8.954856	11.045144	10.001757	11.046900	51
10	8.954499	9.998232	8.956267	11.043733	10.001768	11.045501	50
11	8.955894	9.998220	8.957673	11.042327	10.001780	11.044106	49
12	8.957284	9.998209	8.959075	11.040925	10.001791	11.042716	48
13	8.958670	9.998197	8.960473	11.039527	10.001803	11.041330	47
14	8.960052	9.998186	8.961866	11.038134	10.001814	11.039948	46
15	8.961429	9.998174	8.963254	11.036746	10.001826	11.038571	45
16	8.962801	9.998163	8.964639	11.035361	10.001837	11.037199	44
17	8.964170	9.998151	8.966019	11.033981	10.001849	11.035830	43
18	8.965534	9.998139	8.967394	11.032606	10.001861	11.034466	42
19	8.966893	9.998127	8 968766	11.031234	10.001873	11.033107	41
20	8.968249	9.998116	8.970133	11.029867	10.001884	11.031751	40
21	8.969600	9.998104	8.971496	11.028504	10.001896	11.030400	39
22	8.970947	9.998092	8.972855	11.027145	10.001908	11.029053	38
23	8.972289	9.998080	8.974209	11.025791	10.001920	11.027711	37
24	8.973628	9.998068	8.975560	11.024440	10.001932	11.026372	36
25	8.974962	9.998056	8.976906	11.023094	10 001944	11.025038	35
26	8.976293	9.998044	8.978248	11.021752	10.001956	11.023707	34
27	8.977619	9.998032	8.979586	11.020414	10.001968	11.022381	33
28	8.978941	9.998020	8.980921	11.019079	10.001980	11.021059	32
29	8.980259	9.998008	8.982251	11.017749	10.001992	11.019741	31
30	8.981573	9.997996	8.983577	11.016423	10.002004	11.018427	30
		Sine		Tangent		Secant	Minutes

84 Degrees.

5 Degrees.

Minutes	Sine		Tangent		Secant		
30	8.981573	9.997996	8.983577	11.016423	10.002004	11.018427	30
31	8.982883	9.997984	8.984899	11.015101	10.002016	11.017117	29
32	8.984189	9.997972	8.986217	11.013783	10.002028	11.015811	28
33	8.985491	9.997959	8.987532	11.012468	10.002041	11.014509	27
34	8.986789	9.997947	8.988842	11.011158	10.002053	11.013211	26
35	8.988083	9.997935	8 990149	11.009851	10.002065	11.011917	25
36	8.989374	9.997922	8.991451	11.008549	10.002078	11.010626	24
37	8.990660	9.997910	8.992750	11.007250	10.002090	11.009340	23
38	8.991943	9.997897	8.994045	11.005955	10.002103	11.008057	22
39	8.993222	9.997885	8.995337	11.004663	10.002115	11 006778	21
40	8.994497	9.997873	8.996624	11.003376	10.002127	11.005503	20
41	8.995768	9.997859	8.997908	11.002092	10.002141	11.004232	19
42	8.997036	9.997847	8.999188	11.000812	10.002153	11.002964	18
43	8.998299	9.997835	9.000465	10.999535	10.002165	11.001701	17
44	8.999559	9.997822	9.001738	10.998262	10.002178	11.000441	16
45	9.000816	9.997809	9.003007	10.996993	10-002191	10.999184	15
46	9.002069	9.997797	9.004272	10.995728	10.002203	10.997931	14
47	9.003318	9.997784	9.005534	10.994466	10.002216	10.996682	13
48	9.004563	9.997771	9.006792	10.993208	10.002229	10.995437	12
49	9.005805	9.997758	9.008047	10.991953	10.002242	10.994195	11
50	9.007044	9.997745	9.009298	10.990702	10.002255	10 992956	10
51	9.008278	9.997732	9.010546	10.989454	10.002268	10.991722	9
52	9.009510	9.997719	9.011790	10.988210	10.002281	10.990490	8
53	9.010737	9.997706	9.013031	10.986969	10.002294	10.989263	7
54	9.011962	9.997693	9.014268	10.985732	10.002307	10.988038	6
55	9.013182	9.997680	9.015502	10.984498	10.002320	10.986818	5
56	9.014400	9.997667	9.016733	10.983267	10.002333	10.985600	4
57	9.015613	9.997654	9.017959	10.982041	10.002346	10.984387	3
58	9.016824	9.997641	9.019183	10.980817	10.002359	10.983176	2
59	9.018031	9.997628	9.020403	10.979597	10.002372	10.981969	1
60	9.019235	9.997614	9.021620	10.978380	10.002386	10 980765	0
		Sine		Tangent		Secant	Minutes

84 Degrees.

6 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.019235	9.997614	9.021620	10.978380	10.002386	10.980765	60
1	9.020435	9.997601	9.022834	10.977166	10.002399	10.979565	59
2	9.021632	9.997588	9.024044	10.975956	10.002412	10.978368	58
3	9.022825	9.997574	9.025251	10.974749	10.002426	10.977175	57
4	9.024016	9.997561	9.026455	10.973545	10.002439	10.975984	56
5	9 025203	9.997547	9 027655	10,972345	10.002453	10.974797	55
6	9 026386	9.997534	9.028852	10.971148	10.002466	10.973614	54
7	9.027567	9.997521	9 030046	10.969954	10.002479	10.972433	53
8	9.028744	9 997507	9.031237	10.968763	10.002493	10.971256	52
9	9.029918	9.997493	9 032425	10.967575	10.002507	10.970082	51
10	9.031089	9.997480	9 033609	10.966391	10.002520	10.968911	50
11	9.032257	9.997466	9 034791	10.965209	10.002534	10.967743	49
12	9.033421	9.997452	9.035969	10.964031	10.002548	10.966579	48
13	9.034582	9.997439	9.037144	10.962856	10.002561	10.965418	47
14	9.035741	9 997425	9.038316	10.961684	10.002575	10.964259	46
15	9.036896	9.997411	9 039485	10.960515	10.002589	10.963104	45
16	9.038048	9.997397	9.040651	10.959349	10.002603	10.961952	44
17	9.039197	9.997383	9.041813	10.958187	10.002617	10.960803	43
18	9.040342	9.997369	9.042973	10.957027	10.002631	10.959658	42
19	9.041485	9.997355	9.044130	10.955870	10 002645	10.958515	41
20	9.042625	9.997341	9.045284	10.954716	10.002659	10.957375	40
21	9.043762	9.997327	9.046434	10.953566	10.002673	10.956238	39
22	9.044895	9.997313	9 047582	10.952418	10.002687	10.955105	38
23	9.046026	9.997299	9.048727	10.951273	10.002701	10.953974	37
24	9.047154	9.997285	9.049869	10.950131	10.002715	10.952846	36
25	9 048279	9.997271	9 051008	10.948992	10.002729	10.951721	35
26	9.049400	9.997257	9.052144	10.947856	10.002743	10.950600	34
27	9.050519	9.997242	9.053277	10.946723	10.002758	10.949481	33
28	9.051635	9.997228	9.054407	10.945593	10.002772	10.948365	32
29	9.052748	9.997214	9.055535	10.944465	10.002786	10.947252	31
30	9.053859	9.997199	9.056659	10.943341	10.002801	10.946141	30
		Sine		Tangent		Secant	Minutes

83 Degrees.

6 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.053859	9.997199	9.056659	10.943341	10.002801	10.946141	30
31	9.054966	9.997185	9.057781	10.942219	10 002815	10.945034	29
32	9.056071	9.997170	9.058900	10.941100	10.002830	10.943929	28
33	9.057172	9.997156	9.060016	10.939984	10.002844	10.942828	27
34	9.058271	9.997141	9.061130	10.938870	10.002859	10.941729	26
35	9.059367	9.997127	9.062240	10.937760	10.002873	10.940033	25
36	9.060460	9.997112	9.063348	10.936652	10.002888	10.939540	24
37	9.061551	9.997098	9.064453	10.935547	10.002902	10.938449	23
38	9.062639	9.997083	9.065556	10.934444	10.002917	10.937361	22
39	9.063723	9.997068	9.066655	10.933345	10.002932	10.936277	21
40	9.064806	9.997053	9.067752	10.932248	10.002947	10.935194	20
41	9.065885	9.997039	9.068846	10.931154	10.002961	10.934115	19
42	9.066962	9.997024	9.069938	10.930062	10.002976	10.933038	18
43	9.068036	9.997009	9.071027	10.928973	10 002991	10.931964	17
44	9.069107	9.996994	9.072113	10 927887	10.003006	10.930893	16
45	9.070176	9.996979	9.073197	10.926803	10.003021	10.929824	15
46	9.071242	9.996964	9.074278	10.925722	10.003036	10.928758	14
47	9.072305	9.996949	9.075356	10.924644	10.003051	10.927695	13
48	9.073366	9.996934	9.076432	10.923568	10.003066	10.926634	12
49	9.074424	9.996919	9.077505	10.922495	10 003081	10.925576	11
50	9.075480	9.996904	9.078576	10.921424	10.003096	10.924520	10
51	9.076533	9.996889	9.079644	10.920356	10.003111	10.923467	9
52	9.077583	9.996874	9.080710	10.919290	10.003126	10.922417	8
53	9.078631	9.996858	9.081773	10.918227	10.003142	10.921369	7
54	9.079676	9.996843	9.082833	10.917167	10.003157	10.920324	6
55	9 080719	9.996828	9.083891	10.916109	10.003172	10.919281	5
56	9.081759	9.996812	9.084947	10.915053	10.003188	10.918241	4
57	9.082797	9.996797	9 086000	10.914000	10.003203	10.917203	3
58	9.083832	9.996782	9.087050	10.912950	10.003218	10.916168	2
59	9.084864	9.996766	9.088098	10.911902	10.003234	10.915136	1
60	9.085894	9.996751	9.089144	10.910856	10.003249	10 914106	0
		Sine		Tangent		Secant	Minutes

83 Degrees.

7 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.085895	9.996751	9.089144	10.910856	10.003249	10.914105	60
1	9.086922	9.996735	9.090187	10.909813	10.003265	10.913078	59
2	9.087947	9.996720	9.091228	10.908772	10.003280	10.912053	58
3	9.088970	9.996704	9.092266	10.907734	10.003296	10.911030	57
4	9.089990	9.996688	9.093302	10.906698	10.003312	10.910010	56
5	9.091008	9.996673	9.094335	10.905665	10.003327	10.908992	55
6	9.092024	9.996657	9.095367	10.904633	10.003343	10.907976	54
7	9.093037	9.996641	9.096395	10.903605	10.003359	10.906963	53
8	9.094047	9.996625	9.097422	10.902578	10.003375	10.905953	52
9	9.095056	9.996610	9.098446	10.901554	10.003390	10.904944	51
10	9.096062	9.996594	9.099468	10.900532	10.003406	10.903938	50
11	9.097065	9.996578	9.100487	10.899513	10.003422	10.902935	49
12	9.098066	9.996562	9.101504	10.898496	10.003438	10.901934	48
13	9.099065	9.996546	9.102519	10.897481	10.003454	10.900935	47
14	9.100062	9.996530	9.103532	10.896468	10.003470	10.899938	46
15	9.101056	9.996514	9.104542	10.895458	10.003486	10.898944	45
16	9.102048	9.996498	9.105550	10.894450	10.003502	10.897952	44
17	9.103037	9.996482	9.106556	10.893444	10.003518	10.896963	43
18	9.104025	9.996465	9.107559	10.892441	10.003535	10.895975	42
19	9.105010	9.996449	9.108560	10.891440	10.003551	10.894990	41
20	9.105992	9.996433	9.109559	10.890441	10.003567	10.894008	40
21	9.106973	9.996417	9.110556	10.889444	10.003583	10.893027	39
22	9.107951	9.996400	9.111551	10.888449	10.003600	10.892049	38
23	9.108927	9.996384	9.112543	10.887457	10.003616	10.891073	37
24	9.109901	9.996368	9.113533	10.886467	10.003632	10.890099	36
25	9.110873	9.996351	9.114521	10.885479	10.003649	10.889127	35
26	9.111842	9.996335	9.115507	10.884493	10.003665	10.888158	34
27	9.112809	9.996318	9.116491	10.883509	10.003682	10.887191	33
28	9.113774	9.996302	9.117472	10.882528	10.003698	10.886226	32
29	9.114737	9.996285	9.118452	10.881548	10.003715	10.885263	31
30	9.115698	9.996269	9.119429	10.880571	10.003731	10.884302	30
		Sine		Tangent		Secant	Minutes

82 Degrees.

7 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.115698	9.996269	9.119429	10.880571	10.003731	10.884302	30
31	9.116656	9.996252	9.120404	10.879596	10 003748	10.883344	29
32	9.117612	9.996235	9.121377	10.878623	10.003765	10.882388	28
33	9.118567	9.996218	9.122348	10.877652	10.003782	10.881433	27
34	9.119519	9.996202	9.123317	10.876683	10.003798	10.880481	26
35	9.120469	9.996185	9.124284	10.875716	10.003815	10.879531	25
36	9.121417	9.996168	9.125249	10.874751	10.003832	10.878583	24
37	9.122362	9.996151	9.126211	10.873789	10.003849	10.877638	23
38	9.123306	9.996134	9.127172	10.872828	10.003866	10.876694	22
39	9.124248	9.996117	9.128130	10.871870	10.003883	10.875752	21
40	9.125187	9.996100	9.129087	10.870913	10.003900	10.874813	20
41	9.126125	9.996083	9.130041	10.869959	10.003917	10.873875	19
42	9.127060	9.996066	9.130994	10.869006	10.003934	10.872940	18
43	9.127993	9.996049	9.131944	10.868056	10.003951	10.872007	17
44	9.128925	9.996032	9.132893	10 867107	10.003968	10.871075	16
45	9.129854	9.996015	9.133839	10.866161	10.003985	10.870146	15
46	9.130781	9.995998	9.134783	10.865217	10.004002	10.869219	14
47	9.131706	9.995980	9.135726	10.864274	10.004020	10.868294	13
48	9.132630	9.995963	9.136666	10.863334	10 004037	10.867370	12
49	9.133551	9.995946	9.137605	10.862395	10.004054	10.866449	11
50	9.134470	9.995928	9.138542	10.861458	10.004072	10.865530	10
51	9.135387	9.995911	9.139476	10.860524	10.004089	10.864613	9
52	9.136303	9.995894	9.140409	10.859591	10.004106	10.863697	8
53	9.137216	9.995876	9.141340	10.858660	10.004124	10.862784	7
54	9.138127	9.995859	9.142269	10.857731	10.004141	10.861873	6
55	9 139037	9 995841	9.143196	10.856804	10.004159	10.860963	5
56	9.139944	9.995823	9.144121	10.855879	10.004177	10.860056	4
57	9.140850	9.995806	9 145044	10.854956	10.004194	10.859150	3
58	9 141754	9.995788	9.145965	10.854035	10.004212	10.858245	2
59	9.142655	9.995770	9.146885	10.853115	10.004230	10.857345	1
60	9.143555	9.995753	9.147802	10.852198	10.004247	10 856445	0
		Sine		Tangent		Secant	Minutes

82 Degrees.

8 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.143555	9.995753	9.147802	10 852198	10.004247	10.856445	60
1	9.144453	9.995735	9.148718	10.851282	10.004265	10.855547	59
2	9.145349	9.995717	9 149632	10.850368	10.004283	10.854651	58
3	9.146243	9 995699	9.150544	10.849456	10.004301	10.853757	57
4	9.147136	9 995681	9.151454	10.848546	10 004319	10.852864	56
5	9.148026	9.995663	9.152363	10.847637	10.004337	10.851974	55
6	9.148915	9.995646	9.153269	10.846731	10.004354	10.851085	54
7	9.149801	9.995628	9.154174	10.845826	10.004372	10 850199	53
8	9 150686	9.995609	9.155077	10.844923	10.004391	10.849314	52
9	9.151569	9.995591	9.155978	10.844022	10 004409	10.848431	51
10	9.152451	9.995573	9.156877	10.843123	10.004427	10.847549	50
11	9.153330	9.995555	9.157775	10.842225	10.004445	10.846670	49
12	9.154208	9.995537	9.158671	10.841329	10.004463	10.845792	48
13	9.155083	9.995519	9.159565	10.840435	10.004481	10.844917	47
14	9.155957	9.995500	9.160457	10.839543	10.004500	10 844043	46
15	9.156830	9.995482	9.161347	10.838653	10.004518	10.843170	45
16	9.157700	9.995464	9.162236	10.837764	10.004536	10.842300	44
17	9.158569	9.995445	9.163123	10.836877	10.004355	10.841431	43
18	9.159435	9.995427	9.164008	10.835992	10.004573	10.840565	42
19	9.160300	9.995409	9.164892	10.835108	10.004591	10 839700	41
20	9.161164	9.995390	9.165774	10.834226	10.004610	10.838836	40
21	9.162025	9.995372	9.166654	10.833346	10.004628	10.837975	39
22	9.162885	9.995353	9.167532	10.832468	10.004647	10 837115	38
23	9.163743	9.995334	9.168409	10.831591	10.004666	10.836257	37
24	9 164600	9.995316	9.169284	10.830716	10 004684	10.835400	36
25	9.165454	9.995297	9.170157	10.829843	10.004703	10.834546	35
26	9.166307	9.995278	9.171029	10.828971	10.004722	10.833693	34
27	9.167159	9.995260	9.171899	10.828101	10.004740	10.832841	33
28	9.168008	9.995241	9.172767	10 827233	10.004750	10.831992	32
29	9.168856	9.995222	9.173634	10.826366	10 004778	10.831144	31
30	9.169702	9.995203	9.174500	10.825501	10 004797	10.830298	30
		Sine		Tangent		Secant	Minutes

81 Degrees.

8 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.169702	9.995203	9.174499	10.825501	10.004797	10.830298	30
31	9.170546	9.995184	9.175362	10.824638	10.004816	10.829454	29
32	9 171389	9.995165	9.176224	10.823776	10.004835	10.828611	28
33	9.172230	9.995146	9.177084	10.822916	10.004854	10.827770	27
34	9.173070	9.995127	9.177942	10.822058	10.004873	10.826930	26
35	9.173908	9.995108	9.178799	10.821201	10.004892	10.826092	25
36	9.174744	9.995089	9.179655	10.820345	10.004911	10.825256	24
37	9.175578	9.995070	9.180508	10.819492	10.004930	10.824422	23
38	9.176411	9.995051	9.181360	10.818640	10.004949	10.823589	22
39	9.177242	9.995032	9.182211	10.817789	10.004968	10.822758	21
40	9.178072	9.995013	9.183059	10.816941	10.004987	10.821928	20
41	9.178900	9.994993	9.183907	10.816093	10.005007	10.821100	19
42	9.179726	9.994974	9.184752	10 815248	10.005026	10.820274	18
43	9 180551	9.994955	9.185597	10.814403	10.005045	10.819449	17
44	9.181374	9.994935	9.186439	10.813561	10.005065	10.818626	16
45	9.182196	9.994916	9.187280	10.812720	10.005084	10.817804	15
46	9.183016	9.994896	9.188120	10.811880	10.005104	10.816984	14
47	9.183834	9.994877	9.188957	10.811043	10.005123	10.816166	13
48	9 184651	9.994857	9.189794	10.810206	10.005143	10.815349	12
49	9.185466	9.994838	9.190629	10.809371	10.005162	10.814534	11
50	9 186280	9.994818	9.191462	10.808538	10.005182	10.813730	10
51	9.187092	9.994798	9.192294	10.807706	10.005202	10.812908	9
52	9.187903	9.994779	9 193124	10.806876	10.005221	10.812097	8
53	9.188712	9.994759	9.193953	10.806047	10.005241	10.811288	7
54	9.189519	9.994739	9.194780	10.805220	10.005261	10.810481	6
55	9.190325	9.994719	9.195606	10.804394	10.005281	10.809675	5
56	9.191130	9.994700	9.196430	10.803570	10.005300	10.808870	4
57	9.191933	9.994680	9.197253	10.802747	10.005320	10.808067	3
58	9.192734	9.994660	9.198074	10.801926	10.005340	10 807266	2
59	9.193534	9.994640	9.198894	10.801106	10.005360	10.806466	1
60	9 194332	9.994620	9.199712	10.800288	10.005380	10 805668	0
		Sine		Tangent		Secant	Minutes

81 Degrees.

9 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.194332	9.994620	9.199712	10.800288	10.005380	10.805068	60
1	9.195129	9.994600	9.200529	10.799471	10.005400	10.804871	59
2	9.195925	9.994580	9 201345	10.798655	10.005420	10.804075	58
3	9 196719	9.994560	9 202159	10.797841	10.005440	10 803281	57
4	9.197511	9.994540	9.202971	10.797029	10.005460	10.802489	56
5	9.198302	9.994519	9.203782	10.796218	10.005481	10.801698	55
6	9 199091	9.994499	9.204592	10.795408	10.005501	10.800909	54
7	9.199879	9.994479	9.205400	10.794600	10.005521	10.800121	53
8	9.200666	9.994459	9.206207	10.793793	10.005541	10.799334	52
9	9 201451	9 994438	9.207013	10.792987	10.005562	10 798549	51
10	9.202234	9.994418	9.207817	10.792183	10 005582	10.797766	50
11	9 203017	9.994397	9.208619	10.791381	10.005603	10.796983	49
12	9.203797	9.994377	9.209420	10.790580	10.005623	10.796203	48
13	9.204577	9 994357	9.210220	10.789780	10.005643	10.795423	47
14	9.205354	9.994336	9.211018	10.788982	10.005664	10.794646	46
15	9.206131	9.994316	9 211815	10.788185	10.005684	10.793869	45
16	9.206906	9.994295	9.212611	10.787389	10 005705	10 793094	44
17	9.207679	9.994274	9.213405	10.786595	10.005726	10 792321	43
18	9.208452	9.994254	9.214198	10.785802	10.005746	10.791548	42
19	9.209222	9.994233	9.214989	10.785011	10.005767	10.790778	41
20	9.209992	9.994212	9.215779	10.784221	10.005788	10.790008	40
21	9.210760	9.994191	9.216568	10.783432	10.005809	10.789240	39
22	9.211526	9 994171	9.217356	10.782644	10.005829	10.788474	38
23	9.212291	9.994150	9.218142	10.781858	10.005850	10.787709	37
24	9 213055	9 994129	9.218926	10.781074	10.005871	10.786945	36
25	9.213818	9 994108	9.219710	10.780290	10.005892	10.786182	35
26	9.214579	9 994087	9.220492	10.779508	10.005913	10.785421	34
27	9 215338	9 994066	9 221272	10.778728	10 005934	10.784662	33
28	9.216097	9.994045	9.222052	10.777948	10.005955	10.783903	32
29	9.216854	9.994024	9.222830	10.777170	10.005976	10.783146	31
30	9 217609	9.994003	9.223606	10.776394	10.005997	10.782391	30
		Sine		Tangent		Secant	Minutes

80 Degrees.

9 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.217609	9.994005	9.223606	10 770394	10.005997	10.782391	30
31	9.218363	9.993981	9.224382	10.775618	10.006019	10.781637	29
32	9 219116	9.993960	9.225156	10.774844	10.006040	10.780884	28
33	9.219868	9.993939	9.225929	10.774071	10.006061	10.780132	27
34	9.220618	9.993918	9.226700	10 773300	10.006082	10.779382	26
35	9.221367	9.993896	9 22747	10.772529	10.006104	10 778633	25
36	9.222115	9.993875	9 228239	10.771761	10.006125	10.777885	24
37	9.222861	9.993854	9.229007	10.770993	10.006146	10.777139	23
38	9.223606	9.993832	9.229774	10.770226	10.006168	10.776394	22
39	9.22434	9.993811	9.230539	10.769461	10.006189	10.775651	21
40	9.225092	9.993789	9.231302	10.768698	10.006211	10.774908	20
41	9.225833	9 993768	9.232065	10.767935	10.006232	10.774167	19
42	9.226573	9.993746	9.232826	10 767174	10.006254	10.773427	18
43	9 227311	9.993725	9.233586	10.766414	10.006275	10.772689	17
44	9.228048	9.993703	9.234345	10.765655	10.006297	10.771952	16
45	9.228784	9.993681	9 235103	10.764897	10.006319	10.771216	15
46	9.229519	9.993660	9.235859	10.764141	10.006340	10.770481	14
47	9.230252	9.993638	9.236614	10.763386	10.006362	10.769748	13
48	9 230984	9.993616	9.237368	10.762632	10.006384	10.769016	12
49	9.231715	9.993594	9.238120	10.761880	10.006406	10.768285	11
50	9 232444	9.993572	9.238872	10.761128	10.006428	10.767556	10
51	9.233172	9.993550	9.239622	10 760378	10.006450	10.766828	9
52	9.233899	9.993528	9 240371	10.759629	10.006472	10.766101	8
53	9.234625	9.993507	9.241118	10.758882	10.006493	10.765375	7
54	9.235349	9.993484	9.241865	10.758135	10.006516	10.764651	6
55	9.236073	9.993462	9.242610	10.757390	10.006538	10.763927	5
56	9 236795	9.993440	9.243354	10.756646	10.006560	10.763205	4
57	9.237515	9.993418	9.244097	10.755903	10.006582	10.762485	3
58	9.238235	9.993396	9.244839	10.755161	10.006604	10.761765	2
59	9.238953	9.993374	9.245579	10.754421	10.006626	10.761047	1
60	9 239670	9.993352	9.246319	10.753681	10.006648	10 760330	0
		Sine		Tangent		Secant	Minutes

80 Degrees.

10 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.239670	9.993351	9.246319	10.753681	10.006649	10.760330	60
1	9.240386	9.993329	9.247057	10.752943	10.006671	10.759614	59
2	9.241101	9.993307	9.247794	10.752206	10.006693	10.758899	58
3	9.241814	9.993284	9.248530	10.751470	10.006716	10.758186	57
4	9.242526	9.993262	9.249264	10.750736	10.006738	10.757474	56
5	9.243237	9.993240	9.249998	10.750002	10.006760	10.756763	55
6	9.243947	9.993217	9.250730	10.749270	10.006783	10.756053	54
7	9.244656	9.993195	9.251461	10.748539	10.006805	10.755344	53
8	9.245363	9.993172	9.252191	10.747809	10.006828	10.754637	52
9	9.246069	9.993149	9.252920	10.747080	10.006851	10.753931	51
10	9.246775	9.993127	9.253648	10.746352	10.006873	10.753225	50
11	9.247478	9.993104	9.254374	10.745626	10.006896	10.752522	49
12	9.248181	9.993081	9.255100	10.744900	10.006919	10.751819	48
13	9.248883	9.993059	9.255824	10.744176	10.006941	10.751117	47
14	9.249583	9.993036	9.256547	10.743453	10.006964	10.750417	46
15	9.250282	9.993013	9.257269	10.742731	10.006987	10.749718	45
16	9.250980	9.992990	9.257990	10.742010	10.007010	10.749020	44
17	9.251677	9.992967	9.258710	10.741290	10.007033	10.748323	43
18	9.252373	9.992944	9.259428	10.740572	10.007056	10.747627	42
19	9.253067	9.992921	9.260146	10.739854	10.007079	10.746933	41
20	9.253761	9.992898	9.260862	10.739138	10.007102	10.746239	40
21	9.254453	9.992875	9.261578	10.738422	10.007125	10.745547	39
22	9.255144	9.992852	9.262292	10.737708	10.007148	10.744856	38
23	9.255834	9.992829	9.263005	10.736995	10.007171	10.744166	37
24	9.256523	9.992806	9.263717	10.736283	10.007194	10.743477	36
25	9.257211	9.992783	9.264428	10.735572	10.007217	10.742789	35
26	9.257898	9.992759	9.265138	10.734862	10.007241	10.742102	34
27	9.258583	9.992736	9.265847	10.734153	10.007264	10.741417	33
28	9.259268	9.992713	9.266555	10.733445	10.007287	10.740732	32
29	9.259951	9.992689	9.267261	10.732739	10.007311	10.740049	31
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739367	30
		Sine		Tangent		Secant	Minutes

79 Degrees.

10 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.260633	9.992666	9.267967	10.732033	10.007334	10.739307	30
31	9.261314	9.992643	9.268671	10.731329	10.007357	10.738686	29
32	9.261994	9.992619	9.269375	10.730625	10.007381	10.738006	28
33	9.262673	9.992596	9.270077	10.729923	10.007404	10.737327	27
34	9.263351	9.992572	9.270779	10.729221	10.007428	10.736649	26
35	9.264026	9.992549	9.271479	10.728521	10.007451	10.735973	25
36	9.264703	9.992525	9.272178	10.727822	10.007475	10.735297	24
37	9.265377	9.992501	9.272876	10.727124	10.007499	10.734623	23
38	9.266051	9.992478	9.273573	10.726427	10.007522	10.733949	22
39	9.266723	9.992454	9.274269	10.725731	10.007546	10.733277	21
40	9.267395	9.992430	9.274964	10.725036	10.007570	10.732605	20
41	9.268065	9.992406	9.275658	10.724342	10.007594	10.731935	19
42	9.268734	9.992382	9.276351	10.723649	10.007618	10.731266	18
43	9.269402	9.992358	9.277043	10.722957	10.007642	10.730598	17
44	9.270069	9.992335	9.277734	10.722266	10.007665	10.729931	16
45	9.270735	9.992311	9.278424	10.721576	10.007689	10.729265	15
46	9.271400	9.992287	9.279113	10.720887	10.007713	10.728600	14
47	9.272063	9.992263	9.279801	10.720199	10.007737	10.727937	13
48	9.272726	9.992238	9.280488	10.719512	10.007762	10.727274	12
49	9.273388	9.992214	9.281174	10.718826	10.007786	10.726612	11
50	9.274049	9.992190	9.281858	10.718142	10.007810	10.725951	10
51	9.274708	9.992166	9.282542	10.717458	10.007834	10.725292	9
52	9.275367	9.992142	9.283225	10.716775	10.007858	10.724633	8
53	9.276024	9.992117	9.283907	10.716093	10.007883	10.723976	7
54	9.276681	9.992093	9.284588	10.715412	10.007907	10.723319	6
55	9.277337	9.992069	9.285268	10.714732	10.007931	10.722663	5
56	9.277991	9.992044	9.285947	10.714053	10.007956	10.722009	4
57	9.278644	9.992020	9.286624	10.713376	10.007980	10.721356	3
58	9.279297	9.991996	9.287301	10.712699	10.008004	10.720703	2
59	9.279948	9.991971	9.287977	10.712023	10.008029	10.720052	1
60	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401	0
		Sine		Tangent		Secant	Minutes

79 Degrees.

11 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.280599	9.991947	9.288652	10.711348	10.008053	10.719401	60
1	9.281248	9.991922	9.289326	10.710674	10.008078	10.718752	59
2	9.281897	9.991897	9.289999	10.710001	10.008103	10.718103	58
3	9.282544	9.991873	9.290671	10.709329	10.008127	10.717456	57
4	9.283190	9.991848	9.291342	10.708658	10.008152	10 716810	56
5	9.283836	9.991823	9.292013	10.707987	10.008177	10.716164	55
6	9.284480	9.991799	9.292682	10.707318	10.008201	10.715520	54
7	9.285124	9.991774	9.293350	10.706650	10.008226	10.714876	53
8	9.285766	9.991749	9.294017	10.705983	10.008251	10.714234	32
9	9.286408	9.991724	9.294684	10.705316	10.008276	10.713592	51
10	9.287048	9.991699	9.295349	10.704651	10.008301	10.712952	50
11	9.287687	9.991674	9.296013	10.703987	10.008326	10.712313	49
12	9.288326	9.991649	9.296677	10.703323	10.008351	10.711674	48
13	9.288964	9.991624	9.297339	10.702661	10.008376	10.711036	47
14	9.289600	9.991599	9.298001	10.701999	10.008401	10.710400	46
15	9.290236	9.991574	9.298662	10.701338	10.008426	10.709764	45
16	9.290870	9.991549	9.299322	10.700678	10.008451	10.709130	44
17	9.291504	9.901524	9.299980	10.700020	10.008476	10.708496	43
18	9.292137	9.991498	9.300638	10.699362	10.008502	10.707863	42
19	9.292768	9 991473	9.301295	10.698705	10.008527	10.707232	41
20	9.293399	9.991448	9.301951	10.698049	10.008552	10 706601	40
21	9.294029	9.991423	9.302607	10.697393	10.008577	10.705971	39
22	9 294658	9.991397	9.303261	10.696739	10.008603	10.705342	38
23	9.295286	9.991372	9.303914	10.696086	10.008628	10.704714	37
24	9.295913	9.991346	9.304567	10.695433	10.008654	10.704087	36
25	9.296539	9.991321	9.305218	10.694782	10.008679	10.703461	35
26	9.297164	9.991295	9.305869	10 694131	10.008705	10.702836	34
27	9.297788	9.991270	9.306519	10.693481	10.008730	10.702212	33
28	9.298412	9.991244	9.307167	10.692833	10.008756	10.701588	32
29	9.299034	9 991218	9.307815	10.692185	10.008782	10.700966	31
30	9.299655	9 991193	9.308463	10.691537	10,008807	10.700345	30
		Sine		Tangent		Secant	Minutes

78 Degrees.

11 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.299655	9.991193	9.308463	10.691537	10.008807	10.700345	30
31	9.300276	9.991167	9.309109	10.690891	10.008833	10.699724	29
32	9.300895	9.991141	9.309754	10.690246	10.008859	10.699105	28
33	9.301514	9.991115	9.310398	10.689602	10.008885	10.698486	27
34	9.302132	9.991090	9.311042	10.688958	10.008910	10.697868	26
35	9.302749	9.991064	9.311685	10.688315	10.008936	10.697251	25
36	9.303364	9.991038	9.312327	10.687673	10.008962	10.696636	24
37	9.303979	9.991012	9.312967	10.687033	10.008988	10.696021	23
38	9.304593	9.990986	9.313608	10.686392	10.009014	10.695407	22
39	9.305207	9.990960	9.314247	10.685753	10.009040	10.694793	21
40	9.305819	9.990934	9.314885	10.685115	10.009066	10.694181	20
41	9.306430	9.990908	9.315523	10.684477	10.009092	10.693570	19
42	9.307041	9.990882	9.316159	10.683841	10.009118	10.692959	18
43	9.307650	9.990855	9.316795	10.683205	10.009145	10.692350	17
44	9.308259	9.990829	9.317430	10.682570	10.009171	10.691741	16
45	9.308867	9.990803	9.318064	10.681936	10.009197	10.691133	15
46	9.309474	9.990777	9.318697	10.681303	10.009223	10.690520	14
47	9.310080	9.990750	9.319329	10.680671	10.009250	10.689920	13
48	9.310685	9.990724	9.319961	10.680039	10.009276	10.689315	12
49	9.311289	9 990697	9.320592	10.679408	10.009303	10.688711	11
50	9.311893	9.990671	9.321222	10.678778	10.009329	10.688107	10
51	9.312495	9.990644	9.321851	10.678149	10.009356	10.687505	9
52	9.313097	9.990618	9.322479	10.677521	10.009382	10.686903	8
53	9.313698	9.990591	9.323106	10.676894	10.009409	10.686302	7
54	9.314297	9.990565	9.323733	10.676267	10.009435	10.685703	6
55	9.314896	9.990538	9.324358	10.675642	10.009462	10.685104	5
56	9.315495	9.990511	9.324983	10.675017	10.009489	10.684505	4
57	9.316092	9.990485	9.325607	10.674393	10.009515	10.683908	3
58	9.316688	9.990458	9.326230	10.673770	10 009542	10.683312	2
59	9.317284	9.990431	9.326853	10.673147	10.009569	10.682716	1
60	9.317879	9.990404	9.327474	10.672526	10.009596	10.682121	0
		Sine		Tangent		Secant	Minutes

78 Degrees.

12 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.317879	9.990404	9.327474	10.672526	10.009596	10.082121	60
1	9.318473	9.990377	9.328095	10.671905	10.009623	10.681527	59
2	9.319066	9.990351	9.328715	10.671285	10.009649	10.680934	58
3	9.319658	9.990324	9.329334	10.670666	10.009676	10.680342	57
4	9.320249	9.990297	9.329953	10.670047	10.009703	10 679751	56
5	9.320840	9.990270	9.330570	10.669430	10.009730	10.679160	55
6	9.321430	9.990243	9.331187	10.668813	10.009757	10.678570	54
7	9.322019	9.990215	9 331803	10.668197	10.009785	10.677981	53
8	9.322607	9.990188	9.332418	10.667582	10.009812	10.677393	32
9	9.323194	9.990161	9.333033	10.666967	10.009839	10.676806	51
10	9.323780	9.990134	9.333646	10.666354	10.009866	10.676220	50
11	9.324366	9.990107	9.334259	10.665741	10.009893	10.675634	49
12	9.324951	9.990079	9.334871	10.665129	10.009921	10.675049	48
13	9.325534	9.990052	9.335482	10.664518	10.009948	10.674466	47
14	9.326117	9.990025	9 336093	10.663907	10.009975	10.673883	46
15	9.326700	9.989997	9.336702	10.663298	10.010003	10.673300	45
16	9.327281	9.989970	9.337311	10.662689	10.010030	10.672719	44
17	9.327861	9.989942	9.337919	10.662081	10.010058	10.672138	43
18	9.328442	9.989915	9.338527	10.661473	10.010085	10.671558	42
19	9.329021	9.989887	9.339133	10.660867	10.010113	10.670979	41
20	9.329599	9.989860	9.339739	10 660261	10.010140	10 670401	40
21	9.330176	9.989832	9.340344	10.659656	10.010168	10.669824	39
22	9 330753	9.989804	9.340948	10.659052	10.010196	10.669247	38
23	9.331328	9.989777	9.341552	10.658448	10.010223	10.668672	37
24	9.331903	9.989749	9.342155	10.657845	10.010251	10.668097	36
25	9.332478	9.989721	9.342757	10.657243	10.010279	10.667522	35
26	9 333051	9.989693	9.343358	10.656642	10.010307	10.666949	34
27	9.333624	9.989665	9.343958	10.656042	10.010335	10.666376	33
28	9.334195	9.989637	9.344558	10.655442	10.010363	10.665805	32
29	9.334766	9.989609	9.345157	10.654843	10.010391	10.665234	31
30	9.335337	9.989581	9.345755	10.654245	10.010419	10.664663	30
		Sine		Tangent		Secant	Minutes

77 Degrees.

12 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.335337	9.989581	9.345755	10.654245	10.010419	10.664663	30
31	9.335906	9.989553	9.346353	10.653647	10.010447	10.664094	29
32	9.336475	9.989525	9.346949	10.653051	10.010475	10.663525	28
33	9.337043	9.989497	9.347545	10.652455	10.010503	10.662957	27
34	9.337610	9.989469	9.348141	10.651859	10.010531	10.662390	26
35	9.338176	9.989441	9.348735	10.651265	10.010559	10.661824	25
36	9 338742	9.989413	9.349329	10.650671	10.010587	10.661258	24
37	9.339306	9.989384	9.349922	10.650078	10.010616	10.660694	23
38	9.339871	9.989356	9.350514	10.649486	10.010644	10.660129	22
39	9.340434	9.989328	9.351106	10.648894	10.010672	10.659566	21
40	9.340996	9.989299	9.351697	10.648303	10.010701	10.659004	20
41	9.341558	9.989271	9.352287	10.647713	10.010729	10.658442	19
42	9.342119	9.989243	9.352876	10.647124	10.010757	10.657881	18
43	9.342679	9.989214	9.353465	10.646535	10.010786	10.657321	17
44	9.343239	9.989186	9.354053	10.645947	10.010814	10.656761	16
45	9.343797	9.989157	9.354640	10.645360	10-010843	10.656203	15
46	9.344355	9.989128	9.355227	10.644773	10.010872	10.655645	14
47	9.344912	9.989100	9.355813	10.644187	10.010900	10.655088	13
48	9.345469	9.989071	9.356398	10.643602	10.010929	10.654531	12
49	9.346024	9.989042	9.356982	10.643018	10.010958	10.653976	11
50	9.346579	9.989014	9.357566	10.642434	10.010986	10 653421	10
51	9.347134	9.988985	9.358149	10.641851	10.011015	10.652866	9
52	9.347687	9.988956	9.358731	10.641269	10.011044	10.652313	8
53	9.348240	9.988927	9.359313	10.640687	10.011073	10.651760	7
54	9.348792	9.988898	9.359893	10.640107	10.011102	10.651208	6
55	9.349343	9.988869	9.360474	10.639526	10.011131	10.650657	5
56	9.349893	9.988840	9.361053	10 638947	10.011160	10.650107	4
57	9.350443	9.988811	9.361632	10.638368	10.011189	10.649557	3
58	9.350992	9.988782	9.362210	10.637790	10.011218	10.649008	2
59	9.351540	9.988753	9 362787	10.637213	10.011247	10.648460	1
60	9.352088	9.988724	9.363364	10.636636	10.011276	10.647912	0
		Sine		Tangent		Secant	Minutes

13 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.352088	9.988724	9.363364	10.636636	10.011276	10.647912	60
1	9.352635	9.988695	9.363940	10.636060	10.011305	10.647365	59
2	9.353181	9.988666	9.364516	10.635484	10.011334	10.646819	58
3	9.353726	9.988636	9.365090	10.634910	10.011364	10.646274	57
4	9.354271	9.988607	9.365664	10.634336	10.011393	10.645729	56
5	9 354815	9.988578	9.366237	10,633763	10.011422	10.645185	55
6	9 355358	9.988548	9.366810	10.633190	10.011452	10.644642	54
7	9.355901	9.988519	9.367382	10.632618	10.011481	10.644099	53
8	9.356443	9 988489	9.367953	10.632047	10.011511	10.643557	52
9	9 356984	9.988460	9 368524	10.631476	10.011540	10.643016	51
10	9.357524	9.988430	9.369094	10.630906	10 011570	10.642476	50
11	9.358064	9.988401	9 369663	10.630337	10.011599	10.641936	49
12	9.358603	9.988371	9.370231	10.629769	10.011629	10.641397	48
13	9.359141	9.988342	9.370799	10,629201	10.011658	10.640859	47
14	9.359679	9 988312	9.371367	10.628633	10.011688	10.640321	46
15	9.360215	9.988282	9 371933	10.628067	10.011718	10.639785	45
16	9.360751	9.988252	9.372499	10.627501	10.011748	10.639249	44
17	9.361287	9.988223	9.373064	10.626936	10.011777	10.638713	43
18	9.361822	9.988193	9.373629	10.626371	10.011807	10.638178	42
19	9.362356	9.988163	9.374193	10.625807	10 011837	10.637644	41
20	9.362889	9.988133	9.374756	10.625244	10.011867	10.637111	40
21	9.363422	9.988103	9.375319	10.624681	10.011897	10.636578	39
22	9.363954	9.988073	9 375881	10.624119	10.011927	10.636046	38
23	9.364485	9.988043	9.376442	10.623558	10.011957	10.635515	37
24	9.365016	9.988013	9.377003	10.622997	10.011987	10.634984	36
25	9 365546	9.987983	9 377563	10.622437	10.012017	10.634454	35
26	9.366075	9.987952	9.378123	10.621877	10.012048	10.633925	34
27	9.366604	9.987922	9.378681	10.621319	10.012078	10.633396	33
28	9.367132	9.987892	9.379239	10.620761	10.012108	10.632868	32
29	9.367659	9.987862	9.379797	10 620203	10.012138	10.632341	31
30	9.368185	9.987831	9.380354	10.619646	10.012169	10.631815	30
		Sine		Tangent		Secant	Minutes

76 Degrees.

13 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.368185	9.987831	9.380354	10.619646	10.012169	10.631815	30
31	9.368711	9.987801	9.380910	10.619090	10.012199	10.631289	29
32	9.369236	9.987771	9.381465	10.618535	10.012229	10.630764	28
33	9.369761	9.987740	9.382020	10.617980	10.012260	10.630239	27
34	9.370285	9.987710	9.382575	10.617425	10.012290	10.629715	26
35	9.370808	9.987679	9.383129	10.616871	10.012321	10.629192	25
36	9.371330	9.987649	9.383682	10.616318	10.012351	10.628670	24
37	9.371852	9.987618	9.384234	10.615766	10.012382	10.628148	23
38	9.372373	9.987588	9.384786	10.615214	10.012412	10.627627	22
39	9.372894	9.987557	9.385337	10.614663	10.012443	10.627106	21
40	9.373414	9.987526	9.385888	10.614112	10.012474	10.626586	20
41	9.373933	9.987495	9.386438	10.613562	10.012505	10.626067	19
42	9.374452	9.987465	9.386987	10.613013	10.012535	10.625548	18
43	9.374970	9.987434	9.387536	10.612464	10.012566	10.625030	17
44	9.375487	9.987403	9.388084	10.611916	10.012597	10.624513	16
45	9.376003	9.987372	9.388631	10.611369	10.012628	10.623997	15
46	9.376519	9.987341	9.389178	10.610822	10.012659	10.623481	14
47	9.377035	9.987310	9.389724	10.610276	10.012690	10.622965	13
48	9.377549	9.987279	9.390270	10.609730	10.012721	10.622451	12
49	9.378063	9.987248	9.390815	10.609185	10.012752	10.621937	11
50	9.378577	9.987217	9.391359	10.608641	10.012783	10.621423	10
51	9.379089	9.987186	9.391903	10.608097	10.012814	10.620911	9
52	9.379601	9.987155	9.392447	10.607553	10.012845	10.620399	8
53	9.380113	9.987124	9.392989	10.607011	10.012876	10.619887	7
54	9.380624	9.987092	9.393531	10.606469	10.012908	10.619376	6
55	9.381134	9.987061	9.394073	10.605927	10.012939	10.618806	5
56	9.381643	9.987030	9.394614	10.605386	10.012970	10.618357	4
57	9.382152	9.986998	9.395154	10.604846	10.013002	10.617848	3
58	9.382660	9.986967	9.395693	10.604307	10 013033	10.617340	2
59	9.383168	9.986936	9.396233	10.603767	10.013064	10.616832	1
60	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	0
Minutes		Sine		Tangent		Secant	Minutes

76 Degrees.

14 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.383675	9.986904	9.396771	10.603229	10.013096	10.616325	60
1	9.384181	9.986873	9.397309	10.602691	10.013127	10.615819	59
2	9.384687	9.986841	9.397846	10.602154	10.013159	10.615313	58
3	9.385192	9.986809	9.398383	10.601617	10.013191	10.614808	57
4	9.385697	9.986778	9.398919	10.601081	10.013222	10.614303	56
5	9.386201	9.986746	9.399455	10.600545	10.013254	10.613799	55
6	9.386704	9.986714	9.399990	10.600010	10.013286	10.613296	54
7	9.387207	9.986683	9.400524	10.599476	10.013317	10.612793	53
8	9.387709	9.986651	9.401058	10.598942	10.013349	10.612291	52
9	9.388210	9.986619	9.401591	10.598409	10.013381	10.611790	51
10	9.388711	9.986587	9.402124	10.597876	10.013413	10.611289	50
11	9.389211	9.986555	9.402656	10.597344	10.013445	10.610789	49
12	9.389711	9.986523	9.403187	10.596813	10.013477	10.610289	48
13	9.390210	9.986491	9.403718	10.596282	10.013509	10.609790	47
14	9.390708	9.986459	9.404249	10.595751	10.013541	10.609292	46
15	9.391206	9.986427	9.404778	10.595222	10.013573	10.608794	45
16	9.391703	9.986395	9.405308	10.594692	10.013605	10.608297	44
17	9.392199	9.986363	9.405836	10.594164	10.013637	10.607801	43
18	9.392695	9.986331	9.406364	10.593636	10.013669	10.607305	42
19	9.393190	9.986299	9.406892	10.593108	10.013701	10.606810	41
20	9.393685	9.986266	9.407419	10.592581	10.013734	10.606315	40
21	9.394179	9.986234	9.407945	10.592055	10.013766	10.605821	39
22	9.394673	9.986202	9.408471	10.591529	10.013798	10.605327	38
23	9.395166	9.986169	9.408997	10.591003	10.013831	10.604834	37
24	9.395658	9.986137	9.409521	10.590479	10.013863	10.604342	36
25	9.396150	9.986104	9.410045	10.589955	10.013896	10.603850	35
26	9.396641	9.986072	9.410569	10.589431	10.013928	10.603359	34
27	9.397132	9.986039	9.411092	10.588908	10.013961	10.602868	33
28	9.397621	9.986007	9.411615	10.588385	10.013993	10.602379	32
29	9.398111	9.985974	9.412137	10.587863	10.014026	10.601889	31
30	9.398600	9.985942	9.412658	10.587342	10.014058	10.601400	30
		Sine		Tangent		Secant	Minut

75 Degrees.

14 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.398000	9.985942	9.412658	10.587342	10.014058	10.601400	30
31	9.399088	9.985909	9.413179	10.586821	10.014091	10.600912	29
32	9.399575	9.985876	9.413699	10.586301	10.014124	10.600425	28
33	9.400062	9.985843	9.414219	10.585781	10.014157	10.599938	27
34	9.400549	9.985811	9.414738	10.585262	10.014189	10.599451	26
35	9.401035	9.985778	9.415257	10.584743	10.014222	10.598965	25
36	9.401520	9.985745	9.415775	10.584225	10.014255	10.598480	24
37	9.402005	9.985712	9.416293	10.583707	10.014288	10.597995	23
38	9.402489	9.985679	9.416810	10.583190	10.014321	10.597511	22
39	9.402972	9.985646	9.417326	10.582674	10.014354	10.597028	21
40	9.403455	9.985613	9.417842	10.582158	10.014387	10.596545	20
41	9.403938	9.985580	9.418358	10.581642	10.014420	10.596062	19
42	9.404420	9.985547	9.418873	10.581127	10.014453	10.595580	18
43	9.404901	9.985513	9.419387	10.580613	10.014487	10.595099	17
44	9.405382	9.985480	9.419901	10.580099	10.014520	10.594618	16
45	9.405862	9.985447	9.420415	10.579585	10.014553	10.594138	15
46	9.406341	9.985414	9.420927	10.579073	10.014586	10.593659	14
47	9.406820	9.985380	9.421440	10.578560	10.014620	10.593180	13
48	9.407299	9.985347	9.421951	10.578049	10.014653	10.592701	12
49	9.407777	9.985314	9.422463	10.577537	10.014686	10.592223	11
50	9.408254	9.985280	9.422973	10.577027	10.014720	10.591746	10
51	9.408731	9.985247	9.423484	10.576516	10.014753	10.591269	9
52	9.409207	9.985213	9.423993	10.576007	10.024787	10.590793	8
53	9.409682	9.985180	9.424503	10.575497	10.014820	10.590318	7
54	9.410157	9.985146	9.425011	10.574989	10.014854	10.589843	6
55	9.410632	9.985112	9.425519	10.574481	10.014888	10.589368	5
56	9.411106	9.985079	9.426027	10.573973	10.014921	10.588894	4
57	9.411579	9.985045	9.426534	10.573466	10.014955	10.588421	3
58	9.412052	9.985011	9.427041	10.572959	10.014989	10.587948	2
59	9.412524	9.984978	9.427547	10.572453	10.015022	10.587476	1
60	9.412996	9.984944	9.428052	10.571948	10.015056	10.587004	0
		Sine		Tangent		Secant	Minutes

75 Degrees.

15 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.412996	9.984944	9.428052	10.571948	10.015056	10.587004	60
1	9 413467	9.984910	9.428557	10.571443	10.015090	10.586533	59
2	9.413938	9.984876	9 429002	10.570938	10.015124	10.586062	58
3	9.414408	9.984842	9 429566	10.570434	10.015158	10.585592	57
4	9.414878	9 984808	9.430070	10.569930	10.015192	10.585122	56
5	9.415347	9.984774	9.430573	10.569427	10.015226	10.584653	55
6	9 415815	9.984740	9.431075	10.568925	10.015260	10.584185	54
7	9.416283	9.984706	9.431577	10.568423	10.015294	10.583717	53
8	9.416751	9.984672	9.432079	10.567921	10.015328	10.583249	52
9	9 417217	9 984637	9.432580	10.567420	10.015363	10 582783	51
10	9.417684	9.984603	9.433080	10.566920	10.015397	10.582316	50
11	9 418149	9.984569	9.433580	10.566420	10.015431	10.581851	49
12	9.418615	9.984535	9.434080	10.565920	10.015405	10.581385	48
13	9.419079	9.984500	9 434579	10.565421	10.015500	10.580921	47
14	9.419544	9.984466	9.435078	10.564922	10.015534	10.580456	46
15	9.420007	9.984432	9.435576	10.564424	10.015568	10.579993	45
16	9.420470	9.984397	9.436073	10.563927	10 015603	10 579530	44
17	9.420933	9.984363	9.436570	10.563430	10.015637	10.579067	43
18	9.421395	9.984328	9.437067	10 562933	10.015672	10.578605	42
19	9.421857	9.984293	9.437563	10.562437	10.015707	10.578143	41
20	9.422318	9.984259	9.438059	10.561941	10.015741	10.577682	40
21	9.422778	9.984224	9.438554	10.561446	10.015776	10.577222	39
22	9.423238	9 984189	9.439048	10.560952	10.015811	10.576762	38
23	9.423697	9.984155	9.439543	10.560457	10.015845	10.576303	37
24	9 4241561	9 984120	9.440036	10.559964	10.015880	10.575844	36
25	9.424615	9.984085	9.440529	10.559471	10.015915	10.575385	35
26	9.425073	9.984050	9.441022	10.558978	10.015950	10.574927	34
27	9 425530	9.984015	9.441514	10.558486	10 015985	10.574470	33
28	9.425987	9.983981	9.442006	10.557994	10.016019	10.574013	32
29	9.426443	9.983946	9.442497	10.557503	10.016054	10.573557	31
30	9 426899	9.983910	9.442988	10.557012	10.016090	10.573101	30
		Sine		Tangent		Secant	Minutes

74 Degrees.

15 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.426899	9.983910	9.442988	10.557012	10.016090	10.573101	30
31	9.427354	9.983875	9.443479	10.556521	10.016125	10.572640	29
32	9.427809	9.983840	9.443968	10.556032	10.016160	10.572191	28
33	9.428263	9.983805	9.444458	10.555542	10.016195	10.571737	27
34	9.428717	9.983770	9.444947	10.555053	10.016230	10.571283	26
35	9.429170	9.983735	9.445435	10.554565	10.016265	10.570830	25
36	9.429623	9.983700	9.445923	10.554077	10.016300	10.570377	24
37	9.430075	9.983664	9.446411	10.553589	10.016336	10.569925	23
38	9.430527	9.983629	9.446898	10.553102	10.016371	10.569473	22
39	9.430978	9.983594	9.447384	10.552616	10.016406	10.569022	21
40	9.431429	9.983558	9.447870	10.552130	10.016442	10.568571	20
41	9.431879	9.983523	9.448356	10.551644	10.016477	10.568121	19
42	9.432328	9.983487	9.448841	10.551159	10.016513	10.567672	18
43	9.432778	9.983452	9.449327	10.550674	10.016548	10.567222	17
44	9.433226	9.983416	9.449810	10.550190	10.016584	10.566774	16
45	9.433675	9.983380	9.450294	10.549706	10.016620	10.566325	15
46	9.434122	9.983345	9.450777	10.549223	10.016655	10.565878	14
47	9.434569	9.983309	9.451260	10.548740	10.016691	10.565431	13
48	9.435016	9.983273	9.451743	10.548257	10.016727	10.564984	12
49	9.435462	9.983238	9.452225	10.547775	10.016762	10.564538	11
50	9.435908	9.983202	9.452706	10.547294	10.016798	10.564092	10
51	9.436353	9.983166	9.453187	10.546813	10.016834	10.563647	9
52	9.436798	9.983130	9.453668	10.546332	10.016870	10.563202	8
53	9.437242	9.983094	9.454148	10.545852	10.016906	10.562758	7
54	9.437686	9.983058	9.454628	10.545372	10.016942	10.562314	6
55	9.438129	9.983022	9.455107	10.544893	10.016978	10.561871	5
56	9.438572	9.982986	9.455586	10.544414	10.017014	10.561428	4
57	9.439014	9.982950	9.456064	10.543936	10.017050	10.560986	3
58	9.439456	9.982914	9.456542	10.543458	10.017086	10.560544	2
59	9.439897	9.982878	9.457019	10.542981	10.017122	10.560103	1
60	9.440338	9.982842	9.457496	10.542504	10.017158	10.559662	0
		Sine		Tangent		Secant	Minutes

74 Degrees.

16 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.440338	9.982842	9.457496	10 542504	10.017158	10.559652	60
1	9.440778	9.982805	9.457973	10.542027	10.017195	10.559222	59
2	9.441218	9 9827 69	9 458449	10.541551	10.017231	10.558782	58
3	9.441658	9 982733	9.458925	10.541075	10.017267	10.558342	57
4	9.442096	9 9826 6	9.4594	10.540600	10.017304	10.557904	56
5	9.442535	9.982660	9.459 75	10.540125	10.017340	10.557465	55
6	9.442973	9.982624	9.460349	10.539651	10.017376	10.557027	54
7	9.443410	9.982587	9.460823	10.539177	10.017413	10 556590	53
8	9 443847	9 982551	9.461297	10 538703	10.017449	10.556153	52
9	9.444284	9.982514	9.461770	10.538230	10 017486	10.555716	51
10	9.444720	9.982477	9.462242	10.537758	10.017523	10.555280	50
11	9.445155	9.982441	9.462714	10.537286	10.017559	10.554845	49
12	9.445590	9.982404	9.463186	10.536814	10.017596	10.554410	48
13	9.446025	9.982367	9.463658	10.536342	10.017633	10.553975	47
14	9 446459	9.982331	9.464128	10.535872	10.017669	10 553541	46
15	9.446893	9.982294	9.464599	10 535401	10.017706	10.553107	45
16	9.447326	9.982257	9.465069	10.534931	10.017743	10.552674	44
17	9.447759	9.982220	9.465539	10 534461	10.017780	10.552241	43
18	9.448191	9 982183	9.466008	10.533992	10.017817	10.551809	42
19	9.448623	9 982146	9.466476	10.533524	10.017854	10 551377	41
20	9.449054	9.982109	9.466945	10.533055	10.017891	10.550946	40
21	9.449485	9 982072	9.467413	10 532587	10.017928	10.550515	39
22	9.449915	9.982035	9 467880	10.532120	10.017965	10 550085	38
23	9.450345	9.981998	9.468347	10.531653	10.018002	10 549655	37
24	9 450775	9.981961	9.468814	10.531186	10.018039	10.549225	36
25	9.451204	9.981924	9.469280	10.530720	10.018076	10.548796	35
26	9.451632	9.981886	9.469746	10.530254	10.018114	10.548368	34
27	9.452060	9.981849	9.470211	10.529789	10.018151	10.547940	33
28	9.452488	9.981812	9.470676	10 529324	10.018188	10.547512	32
29	9.452915	9.981774	9.471141	10.528859	10.018226	10.547085	31
30	9.453342	9.981737	9.471605	10.528395	10.018263	10.546658	30
		Sine		Tangent		Secant	Minutes

73 Degrees.

16 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.453342	9.981737	9.471605	10.528395	10.018263	10.546658	30
31	9.453768	9.981699	9.472068	10.527932	10.018301	10.546232	29
32	9 454194	9.981662	9.472532	10.527468	10.018338	10.545806	28
33	9.454619	9.981625	9.472995	10.527005	10.018375	10.545381	27
34	9.455044	9.981587	9.473457	10.526543	10.018413	10.544956	26
35	9.455469	9.981549	9.473919	10.526081	10.018451	10.544531	25
36	9.455893	9.981512	9.474381	10.525619	10.018488	10.544107	24
37	9.456316	9.981474	9.474842	10.525158	10.018526	10.543684	23
38	9.456739	9.981436	9.475303	10.524697	10.018564	10.543261	22
39	9.457162	9.981399	9.475763	10.524237	10.018601	10.542838	21
40	9.457584	9.981361	9.476223	10.523777	10.018639	10.542416	20
41	9.458006	9.981323	9.476683	10.523317	10.018677	10.541994	19
42	9.458427	9.981285	9.477142	10 522858	10.018715	10.541573	18
43	9 458848	9.981247	9.477601	10.522399	10.018753	10.541152	17
44	9.459268	9.981209	9.478059	10.521941	10.018791	10.540732	16
45	9.459688	9.981171	9.478517	10.521483	10.018829	10.540312	15
46	9.460108	9.981133	9.478975	10.521025	10.018867	10.539892	14
47	9.460527	9.981095	9.479432	10.520568	10.018905	10.539473	13
48	9 460946	9.981057	9.479889	10.520111	10.018943	10.539054	12
49	9.461364	9.981019	9.480345	10.519655	10.018981	10.538636	11
50	9.461782	9.980980	9.480801	10.519199	10.019020	10.538218	10
51	9.462199	9.980942	9.481257	10.518743	10.019058	10.537801	9
52	9.462616	9.980904	9 481712	10.518288	10.019096	10.537384	8
53	9.463032	9.980866	9.482167	10.517833	10.019134	10.536968	7
54	9.463448	9.980827	9.482621	10.517379	10.019173	10.536552	6
55	9.463864	9.980789	9.483075	10.516925	10.019211	10.536136	5
56	9.464279	9.980751	9.483529	10.516471	10.019249	10.535721	4
57	9.464694	9,980712	9.483982	10.516018	10.019288	10.535306	3
58	9.465108	9.980673	9.484435	10.515565	10.019327	10.534892	2
59	9.465522	9.980635	9.484887	10.515113	10.019365	10.534478	1
60	9 465935	9.980596	9.485339	10.514661	10.019404	10 534065	0
		Sine		Tangent		Secant	Minutes

73 Degrees.

17 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.465935	9.980596	9.485339	10.514661	10.019404	10.534065	60
1	9.466348	9.980558	9.485791	10.514209	10.019442	10.533652	59
2	9.466761	9.980519	9.486242	10.513758	10.019481	10.533239	58
3	9.467173	9.980480	9.486693	10.513307	10.019520	10.532827	57
4	9.467585	9.980441	9.487143	10.512857	10.019559	10.532415	56
5	9.467996	9.980403	9.487593	10.512407	10.019597	10.532004	55
6	9.468407	9.980364	9.488043	10.511957	10.019636	10.531593	54
7	9.468817	9.980325	9.488492	10.511508	10.019675	10.531183	53
8	9.469227	9.980286	9.488941	10.511059	10.019714	10.530773	52
9	9.469637	9.980247	9.489390	10.510610	10.019753	10.530363	51
10	9.470046	9.980208	9.489838	10.510162	10.019792	10.529954	50
11	9.470455	9.980169	9.490286	10.509714	10.019831	10.529545	49
12	9.470863	9.980130	9.490733	10.509267	10.019870	10.529137	48
13	9.471271	9.980091	9.491180	10.508820	10.019909	10.528729	47
14	9.471678	9.980052	9.491627	10.508373	10.019948	10.528322	46
15	9.472086	9.980012	9.492073	10.507927	10.019988	10.527914	45
16	9.472492	9.979973	9.492519	10.507481	10.020027	10.527508	44
17	9.472898	9.979934	9.492965	10.507035	10.020066	10.527102	43
18	9.473304	9.979895	9.493410	10.506590	10.020105	10.526696	42
19	9.473710	9.979855	9.493854	10.506146	10.020145	10.526290	41
20	9.474115	9.979816	9.494299	10.505701	10.020184	10.525885	40
21	9.474519	9.979776	9.494743	10.505257	10.020224	10.525481	39
22	9.474923	9.979737	9.495186	10.504814	10.020263	10.525077	38
23	9.475327	9.979697	9.495630	10.504370	10.020303	10.524673	37
24	9.475730	9.979658	9.496073	10.503927	10.020342	10.524270	36
25	9.476133	9.979618	9.496515	10.503485	10.020382	10.523867	35
26	9.476536	9.979578	9.496957	10.503043	10.020422	10.523464	34
27	9.476938	9.979539	9.497399	10.502601	10.020461	10.523062	33
28	9.477340	9.979499	9.497841	10.502159	10.020501	10.522660	32
29	9.477741	9.979459	9.498282	10.501718	10.020541	10.522259	31
30	9.478142	9.979419	9.498722	10.501278	10.020581	10.521858	30
		Sine		Tangent		Secant	Minutes

72 Degrees.

17 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.478142	9.979419	9.498722	10.501278	10 020580	10.521858	30
31	9.478542	9.979380	9.499163	10.500837	10.020620	10.521458	29
32	9 478942	9.979340	9.499603	10.500397	10.020660	10.521058	28
33	9.479342	9.979300	9.500042	10.499958	10.020700	10.520658	27
34	9.479741	9.979260	9.500481	10.499519	10.020740	10.520259	26
35	9.480140	9.979220	9.500920	10.499080	10.020780	10.519860	25
36	9.480538	9.979180	9.501359	10.498641	10.020820	10.519462	24
37	9.480937	9.979140	9.501797	10.498203	10.020860	10.519063	23
38	9.481334	9.979100	9.502235	10.497765	10.020900	10.518660	22
39	9.481731	9.979059	9.502672	10.497328	10.020941	10.518269	21
40	9.482128	9.979019	9.503109	10.496891	10.020981	10.517872	20
41	9.482525	9.978979	9.503546	10.496454	10.021021	10.517475	19
42	9.482921	9.978939	9.503982	10 496018	10.021061	10.517079	18
43	9 483316	9.978898	9.504418	10.495582	10.021102	10.516684	17
44	9.483712	9.978858	9.504854	10.495146	10.021142	10.516288	16
45	9.484107	9.978817	9.505289	10.494711	10.021183	10.515893	15
46	9.484501	9.978777	9.505724	10.494276	10.021223	10.515499	14
47	9.484895	9.978736	9.506159	10.493841	10.021264	10.515105	13
48	9 485289	9.978696	9.506593	10.493407	10.021304	10.514711	12
49	9.485682	9.978655	9.507027	10.492973	10.021345	10.514318	11
50	9.486075	9.978615	9.507460	10.492540	10.021385	10.513925	10
51	9.486467	9.978574	9.507893	10.492107	10.021426	10.513533	9
52	9.486859	9.978533	9 508326	10.491674	10.021467	10.513141	8
53	9.487251	9.978493	9.508759	10.491241	10.021507	10.512749	7
54	9.487643	9.978452	9.509191	10.490809	10.021548	10.512357	6
55	9.488033	9.978411	9.509622	10.490378	10.021589	10.511967	5
56	9.488424	9.978370	9.510054	10.489946	10.021630	10.511576	4
57	9.488814	9,978329	9.510485	10.489515	10.021671	10.511186	3
58	9.489204	9.978288	9.510916	10.489084	10.021712	10.510796	2
59	9.489593	9.978247	9.511346	10.488654	10.021753	10.510407	1
60	9 489982	9.978206	9.511776	10.488224	10.021794	10 510018	0
		Sine		Tangent		Secant	Minutes

72 Degrees.

18 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.489982	9.978206	9.511776	10.488224	10.021794	10.510018	60
1	9.490371	9.978165	9.512206	10.487794	10.021835	10.509629	59
2	9.490759	9.978124	9.512635	10.487365	10.021876	10.509241	58
3	9.491147	9.978083	9.513064	10.486936	10.021917	10.508853	57
4	9.491534	9.978042	9.513493	10.486507	10.021958	10.508466	56
5	9.491922	9.978001	9.513921	10.486079	10.021999	10.508078	55
6	9.492308	9.977959	9.514349	10.485651	10.022041	10.507692	54
7	9.492695	9.977918	9.514777	10.485223	10.022082	10.507305	53
8	9.493081	9.977878	9.515204	10.484796	10.022122	10.506919	52
9	9.493466	9.977835	9.515631	10.484369	10.022165	10.506534	51
10	9.493851	9.977794	9.516057	10.483943	10.022206	10.506149	50
11	9.494236	9.977752	9.516484	10.483516	10.022248	10.505764	49
12	9.494620	9.977711	9.516910	10.483090	10.022289	10.505380	48
13	9.495005	9.977669	9.517335	10.482665	10.022331	10.504995	47
14	9.495388	9.977628	9.517761	10.482239	10.022372	10.504612	46
15	9.495772	9.977586	9.518185	10.481815	10.022414	10.504228	45
16	9.496154	9.977544	9.518610	10.481390	10.022456	10.503846	44
17	9.496537	9.977503	9.519034	10.480966	10.022497	10.503463	43
18	9.496919	9.977461	9.519458	10.480542	10.022539	10.503081	42
19	9.497301	9.977419	9.519882	10.480118	10.022581	10.502699	41
20	9.497682	9.977377	9.520305	10.479695	10.022623	10.502318	40
21	9.498063	9.977335	9.520728	10.479272	10.022665	10.501937	39
22	9.498444	9.977293	9.521151	10.478849	10.022707	10.501556	38
23	9.498824	9.977251	9.521573	10.478427	10.022749	10.501176	37
24	9.499204	9.977209	9.521995	10.478005	10.022791	10.500796	36
25	9.499584	9.977167	9.522417	10.477583	10.022833	10.500416	35
26	9.499963	9.977125	9.522838	10.477162	10.022875	10.500037	34
27	9.500342	9.977083	9.523259	10.476741	10.022917	10.499658	33
28	9.500721	9.977041	9.523679	10.476321	10.022959	10.499279	32
29	9.501096	9.976999	9.524100	10.475900	10.023001	10.498901	31
30	9.501476	9.976957	9.524520	10.475480	10.023043	10.498524	30
		Sine		Tangent		Secant	Minutes

71 Degrees.

18 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.501476	9.970957	9.524520	10.475480	10.023043	10.498524	30
31	9.501854	9.976914	9.524939	10.475061	10.023086	10.498146	29
32	9.502231	9.976872	9.525359	10.474641	10.023128	10.497769	28
33	9.502607	9.976830	9.525778	10.474222	10.023170	10.497393	27
34	9.502984	9.976787	9.526197	10.473803	10.023213	10.497016	26
35	9.503360	9.976745	9.526615	10.473385	10.023255	10.496640	25
36	9.503735	9.976702	9.527033	10.472967	10.023298	10.496265	24
37	9.504110	9.976660	9.527451	10.472549	10.023340	10.495890	23
38	9.504485	9.976617	9.527868	10.472132	10.023383	10.495515	22
39	9.504860	9.976574	9.528285	10.471715	10.023426	10.495140	21
40	9.505234	9.976532	9.528702	10.471298	10.023468	10.494766	20
41	9.505608	9.976489	9.529119	10.470881	10.023511	10.494392	19
42	9.505981	9.976446	9.529535	10.470465	10.023554	10.494019	18
43	9.506354	9.976404	9.529950	10.470050	10.023596	10.493646	17
44	9.506727	9.976361	9.530366	10.469634	10.023639	10.493273	16
45	9.507099	9.976318	9.530781	10.469219	10.023682	10.492901	15
46	9.507471	9.976275	9.531196	10.468804	10.023725	10.492529	14
47	9.507843	9.976232	9.531611	10.468389	10.023768	10.492157	13
48	9.508214	9.976189	9.532025	10.467975	10.023811	10.491786	12
49	9.508585	9.976146	9.532439	10.467561	10.023854	10.491415	11
50	9.508956	9.976103	9.532853	10.467147	10.023897	10.491044	10
51	9.509326	9.976060	9.533266	10.466734	10.023940	10.490674	9
52	9.509696	9.976017	9.533679	10.466321	10.023983	10.490304	8
53	9.510065	9.975974	9.534092	10.465908	10.024026	10.489935	7
54	9.510434	9.975930	9.534504	10.465496	10.024070	10.489566	6
55	9.510803	9.975887	9.534916	10.465084	10.024113	10.489197	5
56	9.511172	9.975844	9.535328	10.464672	10.024156	10.488828	4
57	9.511540	9.975800	9.535739	10.464261	10.024200	10.488460	3
58	9.511907	9.975757	9.536150	10.463850	10 024243	10.488093	2
59	9.512275	9.975713	9.536561	10.463439	10.024287	10.487725	1
60	9.512642	9.975670	9.536972	10.463028	10.024330	10.487358	0
		Sine		Tangent		Secant	Minutes

71 Degrees.

19 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.512642	9.975079	9.530972	10.463020	10.024330	10.487350	60
1	9.513009	9.975026	9.537382	10.462618	10.024374	10.487991	59
2	9.513375	9.975583	9.537792	10.462208	10.024417	10.486025	58
3	9.513741	9.975539	9.538202	10.461798	10.024461	10.486259	57
4	9.514107	9.975496	9.538611	10.461389	10.024504	10.485893	56
5	9.514472	9.975452	9.539020	10.460980	10.024548	10.485528	55
6	9.514837	9.975408	9.539429	10.460571	10.024592	10.485163	54
7	9.515202	9.975365	9.539837	10.460163	10.024635	10.484798	53
8	9.515566	9.975321	9.540245	10.459755	10.024679	10.484434	52
9	9.515930	9.975277	9.540653	10.459347	10.024723	10.484070	51
10	9.516294	9.975233	9.541001	10.458939	10.024767	10.483706	50
11	9.516657	9.975189	9.541468	10.458532	10.024811	10.483343	49
12	9.517020	9.975145	9.541875	10.458125	10.024855	10.482980	48
13	9.517382	9.975101	9.542281	10.457719	10.024899	10.482618	47
14	9.517745	9.975057	9.542688	10.457312	10.024945	10.482255	46
15	9.518107	9.975013	9.543094	10.456900	10.024987	10.481893	45
16	9.518468	9.974969	9.543499	10.456501	10.025031	10.481532	44
17	9.518829	9.974925	9.543905	10.456095	10.025075	10.481171	43
18	9.519190	9.974880	9.544310	10.455690	10.025120	10.480810	42
19	9.519551	9.974836	9.544715	10.455285	10.025164	10.480449	41
20	9.519911	9.974792	9.545119	10.454881	10.025208	10.480089	40
21	9.520271	9.974747	9.545524	10.454476	10.025253	10.479729	39
22	9.520631	9.974703	9.545928	10.454072	10.025297	10.479369	38
23	9.520990	9.974659	9.546331	10.453669	10.025341	10.479010	37
24	9.521349	9.974614	9.546735	10.453265	10.025386	10.478651	36
25	9.521707	9.974570	9.547138	10.452862	10.025430	10.478293	35
26	9.522066	9.974525	9.547540	10.452460	10.025475	10.477934	34
27	9.522423	9.974481	9.547943	10.452057	10.025519	10.477577	33
28	9.522781	9.974436	9.548345	10.451655	10.025564	10.477219	32
29	9.523138	9.974391	9.548747	10.451253	10.025609	10.476862	31
30	9.523495	9.974347	9.549149	10.450851	10.025653	10.476505	30
		Sine		Tangent		Secant	Minutes

70 Degrees.

19 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.523495	9.974347	9.549149	10.450851	10.025053	10.470505	30
31	9.523852	9.974302	9.549550	10.450450	10.025698	10.476148	29
32	9.524208	9.974257	9.549951	10.450049	10.025743	10.475792	28
33	9.524564	9.974212	9.550352	10.449648	10.025788	10.475436	27
34	9.524920	9.974167	9.550752	10.449248	10.025833	10.475080	26
35	9.525275	9.974122	9.551152	10.448848	10.025878	10.474725	25
36	9.525630	9.974077	9.551552	10.448448	10.025923	10.474370	24
37	9.525984	9.974032	9.551952	10.448048	10.026968	10.474016	23
38	9.526339	9.973987	9.552351	10.447649	10.026013	10.473661	22
39	9.526693	9.973942	9.552750	10.447250	10.026058	10.473307	21
40	9.527046	9.973897	9.553149	10.446851	10.026103	10.472954	20
41	9.527400	9.973852	9.553548	10.446452	10.026148	10.472600	19
42	9.527753	9.973807	9.553946	10.446054	10.026193	10.472247	18
43	9.528105	9.973761	9.554344	10.445656	10.026239	10.471895	17
44	9.528458	9.973716	9.554741	10.445259	10.026284	10.471542	16
45	9.528810	9.973671	9.555139	10.444861	10.026329	10.471190	15
46	9.529161	9.973625	9.555536	10.444464	10.026375	10.470839	14
47	9.529513	9.973580	9.555933	10.444067	10.026420	10.470487	13
48	9.529864	9.973535	9.556329	10.443671	10.026465	10.470136	12
49	9.530215	9.973489	9.556725	10.443275	10.026511	10.469785	11
50	9.530565	9.973443	9.557121	10.442879	10.026557	10.469435	10
51	9.530915	9.973398	9.557517	10.442483	10.026602	10.469085	9
52	9.531265	9.973352	9.557912	10.442088	10.026648	10.468735	8
53	9.531614	9.973307	9.558308	10.441692	10.026693	10.468386	7
54	9.531962	9.973261	9.558702	10.441298	10.026739	10.468037	6
55	9.532312	9.973215	9.559097	10.440903	10.026785	10.467688	5
56	9.532661	9.973169	9.559491	10.440509	10.026831	10.467339	4
57	9.533009	9.973124	9.559885	10.440115	10.026876	10.466991	3
58	9.533357	9.973078	9.560279	10.439721	10.026922	10.466643	2
59	9.533704	9.973032	9.560673	10.439327	10.026968	10.466296	1
60	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948	0
		Sine		Tangent		Secant	Minutes

70 Degrees.

20 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.534052	9.972986	9.561066	10.438934	10.027014	10.465948	60
1	9.534399	9.972940	9.561459	10.438541	10.027060	10.465601	59
2	9.534745	9.972894	9.561851	10.438149	10.027106	10.465255	58
3	9.535092	9.972848	9.562244	10.437756	10.027152	10.464908	57
4	9.535437	9.972802	9.562636	10.437364	10.027198	10 464563	56
5	9.535783	9.972755	9.563028	10.436972	10.027245	10.464217	55
6	9.536129	9.972709	9.563419	10.436581	10.027291	10.463871	54
7	9.536474	9.972663	9.563811	10.436189	10.027337	10.463526	53
8	9.536818	9.972617	9.564202	10.435798	10.027383	10.463182	32
9	9.537163	9.972570	9.564592	10.435408	10.027430	10.462837	51
10	9.537507	9.972524	9.564983	10.435017	10.027476	10.462493	50
11	9.537851	9.972477	9.565373	10.434627	10.027523	10.462149	49
12	9.538194	9.972431	9.565763	10.434237	10.027569	10.461806	48
13	9.538538	9.972385	9.566153	10.433847	10.027615	10.461462	47
14	9.538880	9.972338	9.566542	10.433458	10.027662	10.461120	46
15	9.539223	9.972291	9.566932	10.433068	10.027709	10.460777	45
16	9.539565	9.972245	9.567321	10.432679	10.027755	10.460435	44
17	9.539907	9.972198	9.567709	10.432291	10.027802	10.460093	43
18	9.540249	9.972151	9.568098	10.431902	10.027849	10.459751	42
19	9.540590	9.972105	9.568486	10.431514	10.027895	10.459410	41
20	9.540931	9.972058	9.568875	10.431127	10.027942	10.459069	40
21	9.541272	9.972011	9.569261	10.430739	10.027989	10.458728	39
22	9.541613	9.971964	9.569648	10.430352	10.028036	10.458387	38
23	9.541953	9.971917	9.570035	10.429965	10.028083	10.458047	37
24	9.542293	9.971870	9.570422	10.429578	10.028130	10.457707	36
25	9.542632	9.971823	9.570809	10.429191	10.028177	10.457368	35
26	9 542971	9.971776	9.571195	10.428805	10.028224	10.457029	34
27	9.543310	9.971729	9.571581	10.428419	10.028271	10.456690	33
28	9.543649	9.971682	9.571967	10.428033	10.028318	10.456351	32
29	9.543987	9.971635	9.572352	10.427648	10.028365	10.456013	31
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675	30
		Sine		Tangent		Secant	Minutes

69 Degrees.

20 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.544325	9.971588	9.572738	10.427262	10.028412	10.455675	30
31	9.544663	9.971540	9.573123	10.426877	10.028460	10.455337	29
32	9.545001	9.971493	9.573507	10.426493	10.028507	10.454999	28
33	9.545338	9.971446	9.573892	10.426108	10.028554	10.454662	27
34	9.545674	9.971398	9.574276	10.425724	10.028602	10.454326	26
35	9.546011	9.971351	9.574660	10.425340	10.028649	10.453989	25
36	9.546347	9.971303	9.575044	10.424956	10.028697	10.453653	24
37	9.546683	9.971256	9.575427	10.424573	10.028744	10.453317	23
38	9.547019	9.971208	9.575810	10.424190	10.028792	10.452981	22
39	9.547354	9.971161	9.576193	10.423807	10.028839	10.452646	21
40	9.547689	9.971113	9.576576	10.423424	10.028887	10.452311	20
41	9.548024	9.971065	9.576958	10.423042	10.028935	10.451976	19
42	9.548358	9.971018	9.577341	10.422659	10.028982	10.451642	18
43	9.548693	9.970970	9.577723	10.422277	10.029030	10.451307	17
44	9.549027	9.970922	9.578104	10.421896	10.029078	10.450973	16
45	9.549360	9.970874	9.578486	10.421514	10.029126	10.450640	15
46	9.549693	9.970826	9.578867	10.421133	10.029174	10.450307	14
47	9.550026	9.970779	9.579248	10.420752	10.029221	10.449974	13
48	9.550359	9.970731	9.579629	10.420371	10.029269	10.449641	12
49	9.550692	9.970683	9.580009	10.419991	10.029317	10.449308	11
50	9.551024	9.970635	9.580389	10.419611	10.029365	10.448976	10
51	9.551356	9.970586	9.580769	10.419231	10.029414	10.448644	9
52	9.551687	9.970538	9.581149	10.418851	10.029462	10.448313	8
53	9.552018	9.970490	9.581528	10.418472	10.029510	10.447982	7
54	9.552349	9.970442	9.581907	10.418093	10.029558	10.447651	6
55	9.552680	9.970394	9.582286	10.417714	10.029606	10.447320	5
56	9.553010	9.970345	9.582665	10 417335	10.029655	10.446990	4
57	9.553341	9.970297	9.583043	10.416957	10.029703	10.446659	3
58	9.553670	9.970249	9.583422	10.416578	10.029751	10.446330	2
59	9.554000	9.970200	9.583800	10.416200	10.029800	10.446000	1
60	9.554329	9.970152	9.584177	10.415823	10.029848	10.445671	0
		Sine		Tangent		Secant	Minutes

69 Degrees.

21 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.554329	9.970152	9.584177	10 415823	10.029848	10.445671	60
1	9.554658	9.970103	9.584555	10.415445	10.029897	10.445342	59
2	9.554987	9 970055	9 584932	10.415068	10.029945	10.445013	58
3	9.555315	9 970006	9.585309	10.414691	10.029994	10.444685	57
4	9.555643	9 969957	9.585686	10.414314	10 030043	10.444357	56
5	9.555971	9.969909	9.586062	10.413938	10.030091	10.444029	55
6	9.556299	9.969860	9.586439	10.413561	10.030140	10.443701	54
7	9.556626	9.969811	9.586815	10.413185	10.030189	10 443374	53
8	9 556953	9 969762	9.587190	10 412810	10.030238	10.443047	52
9	9.557280	9.969714	9.587506	10.412434	10 030286	10.442720	51
10	9.557606	9.969665	9.587941	10.412059	10.030335	10.442394	50
11	9.557932	9.969616	9.588316	10.411684	10.030384	10.442068	49
12	9.558258	9 969567	9.588691	10.411309	10.030433	10.441742	48
13	9.558583	9.969518	9.589066	10.410934	10.030482	10.441417	47
14	9 558909	9.969469	9.589440	10.410560	10.030531	10 441091	46
15	9.559234	9.969420	9.589814	10.410186	10.030580	10.440766	45
16	9.559558	9.969370	9.590188	10.409812	10.030630	10.440442	44
17	9.559883	9.969321	9.590562	10 409438	10.030679	10.440117	43
18	9.560207	9 969272	9.590935	10.409065	10.030728	10.439793	42
19	9.560531	9.969223	9.591308	10.408692	10.030777	10 439469	41
20	9.560855	9.969173	9 591681	10.408319	10.030827	10.439145	40
21	9.561178	9.969124	9.592054	10.407946	10.030876	10.438822	39
22	9.561501	9.969075	9 592426	10.407574	10.030925	10.438499	38
23	9.561824	9.969025	9.592798	10.407202	10.030975	10 438176	37
24	9 562146	9.968976	9.593170	10.406830	10.031024	10.437854	36
25	9.562468	9.968926	9.593542	10.406458	10.031074	10.437532	35
26	9.562790	9 968877	9.593914	10.406086	10.031123	10.437210	34
27	9.563112	9.968827	9.594285	10.405715	10.031173	10.436888	33
28	9.563434	9.968777	9.594656	10 405344	10.031223	10.436566	32
29	9 563755	9.968728	9.595027	10.404973	10 031272	10.436245	31
30	9.564075	9.968678	9.595397	10 404603	10.031322	10.435925	30
		Sine		Tangent		Secant	Minutes

68 Degrees.

21 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.564075	9.968678	9.595397	10.404603	10.031322	10.435925	30
31	9.564396	9.968628	9.595768	10.404232	10.031372	10.435604	29
32	9 564716	9.968578	9.596138	10.403862	10.031422	10.435284	28
33	9.565036	9.968528	9.596508	10.403492	10.031472	10.434964	27
34	9.565356	9.968479	9.596878	10.403122	10.031521	10.434644	26
35	9.565676	9.968429	9.597247	10.402753	10.031571	10.434324	25
36	9.565995	9.968379	9.597616	10.402384	10.031621	10.434005	24
37	9.566314	9.968328	9.597985	10.402015	10.031672	10.433686	23
38	9.566632	9.968278	9.598354	10.401646	10.031722	10.433368	22
39	9.566951	9.968228	9.598722	10.401278	10.031772	10.433049	21
40	9.567269	9.968178	9.599091	10.400909	10.031822	10.432731	20
41	9.567587	9.968128	9.599459	10.400541	10.031872	10.432413	19
42	9.567904	9.968078	9.599827	10 400173	10.031922	10.432096	18
43	9.568222	9.968027	9.600194	10.399806	10.031973	10.431778	17
44	9.568539	9.967977	9.600562	10.399438	10.032023	10.431461	16
45	9.568855	9.967927	9.600929	10.399071	10.032073	10.431145	15
46	9.569172	9.967876	9.601296	10.398704	10.032124	10.430828	14
47	9.569488	9.967826	9.601662	10.398338	10.032174	10.430512	13
48	9 569804	9.967775	9.602029	10.397971	10.032225	10.430196	12
49	9.570120	9.967725	9.602395	10.397605	10.032275	10.429880	11
50	9.570435	9.967674	9.602761	10.397239	10.032326	10.429565	10
51	9.570751	9.967623	9.603127	10.396873	10.032377	10.429249	9
52	9.571066	9.967573	9.603493	10.396507	10.032427	10.428934	8
53	9.571380	9.967522	9.603858	10.396142	10.032478	10.428620	7
54	9.571695	9.967471	9.604223	10.395777	10.032529	10.428305	6
55	9.572009	9.967420	9.604588	10.395412	10.032580	10.427991	5
56	9.572323	9.967370	9.604953	10.395047	10.032630	10.427677	4
57	9.572636	9.967319	9.605317	10.394683	10.032681	10.427364	3
58	9.572949	9.967268	9.605682	10.394318	10.032732	10.427051	2
59	9.573263	9.967217	9.606046	10.393954	10.032783	10.426737	1
60	9 573575	9.967166	9.606410	10.393590	10.032834	10.426425	0
		Sine		Tangent		Secant	Minutes

68 Degrees.

22 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.573575	9.967166	9.606410	10.393590	10.032834	10.426425	60
1	9.573888	9.967115	9.606773	10.393227	10.032885	10.426112	59
2	9.574200	9.967064	9.607137	10.392863	10.032936	10.425800	58
3	9.574512	9 967013	9.607500	10.392500	10.032987	10.425488	57
4	9.574824	9.966961	9.607863	10.392137	10.033039	10.425176	56
5	9.575136	9.966910	9.608225	10.391775	10.033090	10.424864	55
6	9.575447	9.966859	9.608588	10.391412	10.033141	10.424553	54
7	9.575758	9.966807	9.608950	10.391050	10.033193	10.424242	53
8	9 576068	9.966756	9.609312	10 390688	10.033244	10.423932	52
9	9.576379	9.966705	9.609674	10.390326	10 033295	10.423621	51
10	9.576689	9.966653	9.610036	10.389964	10.033347	10.423311	50
11	9.576999	9.966602	9.610397	10.389603	10.033398	10.423001	49
12	9.577309	9.966550	9.610759	10.389241	10.033450	10.422691	48
13	9.577618	9.966499	9.611120	10.388880	10.033501	10.422382	47
14	9.577927	9.966447	9.611480	10.388520	10.033553	10.422073	46
15	9.578236	9.966395	9.611841	10.388159	10.033605	10.421764	45
16	9.578545	9.966344	9.612201	10.387799	10.033656	10.421455	44
17	9.578854	9.966292	9.612561	10.387439	10.033708	10.421146	43
18	9.579162	9.966240	9.612921	10.387079	10.033760	10.420838	42
19	9.579469	9.966188	9.613281	10.386719	10.033812	10.420531	41
20	9.579777	9.966137	9 613641	10.386359	10.033863	10.420223	40
21	9.580085	9.966085	9.614000	10.386000	10.033915	10.419915	39
22	9.580392	9.966033	9.614359	10.385641	10.033967	10.419608	38
23	9.580699	9.965981	9.614718	10.385282	10.034019	10 419301	37
24	9.581005	9.965928	9.615077	10.384923	10.034072	10.418995	36
25	9.581312	9.965876	9.615435	10.384565	10.034124	10.418688	35
26	9.581618	9.965824	9.615793	10.384207	10.034176	10.418382	34
27	9.581924	9.965772	9.616151	10.383849	10.034228	10.418076	33
28	9.582229	9.965720	9.616509	10 383491	10.034280	10.417771	32
29	9.582535	9.965668	9.616867	10.383133	10.034332	10.417465	31
30	9.582840	9.965615	9.617224	10.382776	10.034385	10.417160	30
		Sine		Tangent		Secant	Minutes

67 Degrees.

22 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.582840	9.965615	9 617224	10.382776	10.034385	10.417160	30
31	9.583145	9.965563	9.617582	10.382418	10.034437	10.416855	29
32	9 583449	9.965511	9.617939	10.382061	10.034489	10.416551	28
33	9.583754	9.965458	9.618295	10.381705	10.034542	10.416246	27
34	9.584058	9.965406	9.618652	10.381348	10.034594	10.415942	26
35	9.584361	9.965353	9.619008	10.380992	10.034647	10.415639	25
36	9.584665	9.965301	9.619365	10.380635	10.034699	10.415335	24
37	9.584968	9.965248	9.619721	10.380279	10.034752	10.415032	23
38	9.585272	9.965195	9.620076	10.379924	10.034705	10.414728	22
39	9.585574	9.965143	9.620432	10.379568	10.034857	10.414426	21
40	9.585877	9.965090	9.620787	10.379213	10.034910	10.414123	20
41	9.586180	9.965037	9.621142	10.378858	10.034963	10.413820	19
42	9.586482	9.964984	9.621497	10 378503	10.035016	10.413518	18
43	9 586784	9.964931	9.621852	10.378148	10.035069	10.413216	17
44	9.587085	9.964879	9.622207	10.377793	10.035121	10.412915	16
45	9.587386	9.964826	9.622561	10.377439	10.035174	10.412614	15
46	9.587688	9.964773	9.622915	10.377085	10.035227	10.412312	14
47	9.587988	9.964719	9.623269	10.376731	10.035281	10.412012	13
48	9 588289	9.964666	9.623623	10.376377	10.035334	10.411711	12
49	9.588590	9.964613	9.623976	10.376024	10.035387	10.411410	11
50	9 588890	9.964560	9.624330	10.375670	10.035440	10.411110	10
51	9.589190	9.964507	9.624683	10.375317	10.035493	10.410810	9
52	9.589489	9.964454	9 625036	10.374964	10.035546	10.410511	8
53	9.589789	9.964400	9.625388	10.374612	10.035600	10.410211	7
54	9.590088	9.964347	9.625741	10.374259	10.035653	10.409912	6
55	9.590387	9.964294	9.626093	10.373907	10.035706	10.409613	5
56	9.590686	9.964240	9.626445	10.373555	10.035760	10.409314	4
57	9.590984	9.964187	9.626797	10.373203	10.035813	10.409016	3
58	9.591282	9.964133	9.627149	10.372851	10.035867	10.408718	2
59	9.591580	9.964080	9.627501	10.372499	10.035920	10.408420	1
60	9 591878	9.964026	9.627852	10.372148	10.035974	10 408122	0
		Sine		Tangent		Secant	Minutes

67 Degrees.

23 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.591878	9.964026	9.627852	10.372148	10.035974	10.408122	60
1	9.592175	9.963972	9.628203	10.371797	10.036028	10.407825	59
2	9.592473	9.963919	9.628554	10.371446	10.036081	10.407527	58
3	9.592770	9.963865	9.628905	10.371095	10.036135	10.407230	57
4	9.593067	9.963811	9.629255	10.370745	10.036189	10.406933	56
5	9.593363	9.963757	9.629606	10.370394	10.036243	10.406637	55
6	9.593659	9.963704	9.629956	10.370044	10.036296	10.406341	54
7	9.593955	9.963650	9.630306	10.369694	10.036350	10.406045	53
8	9.594251	9.963596	9.630656	10.369344	10.036404	10.405749	52
9	9.594547	9.963542	9.631005	10.368995	10.036458	10.405453	51
10	9.594842	9.963488	9.631354	10.368646	10.036512	10.405158	50
11	9.595137	9.963434	9.631704	10.368296	10.036566	10.404863	49
12	9.595432	9.963379	9.632053	10.367947	10.036621	10.404568	48
13	9.595727	9.963325	9.632401	10.367599	10.036675	10.404273	47
14	9.596021	9.963271	9.632750	10.367250	10.036729	10.403979	46
15	9.596315	9.963217	9.633098	10.366902	10.036783	10.403685	45
16	9.596609	9.963162	9.633447	10.366553	10.036838	10.403391	44
17	9.596903	9.963108	9.633795	10.366205	10.036892	10.403097	43
18	9.597196	9.963054	9.634143	10.365857	10.036946	10.402804	42
19	9.597490	9.962999	9.634490	10.365510	10.037001	10.402510	41
20	9.597783	9.962945	9.634838	10.365162	10.037055	10.402217	40
21	9.598075	9.962890	9.635185	10.364815	10.037110	10.401925	39
22	9.598368	9.962836	9.635532	10.364468	10.037164	10.401632	38
23	9.598660	9.962781	9.635879	10.364121	10.037219	10.401340	37
24	9.598952	9.962727	9.636226	10.363774	10.037273	10.401048	36
25	9.599244	9.962672	9.636572	10.363428	10.037328	10.400756	35
26	9.599536	9.962617	9.636918	10.363082	10.037383	10.400464	34
27	9.599827	9.962562	9.637265	10.362735	10.037438	10.400173	33
28	9.600118	9.962508	9.637611	10.362389	10.037492	10.399882	32
29	9.600409	9.962453	9.637956	10.362044	10.037547	10.399591	31
30	9.600700	9.962398	9.638302	10.361698	10.037602	10.399300	30
		Sine		Tangent		Secant	Minutes

66 Degrees.

23 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.600700	9.962398	9.638302	10.361698	10.037602	10.399300	30
31	9.600990	9.962343	9.638647	10.361353	10.037657	10.399010	29
32	9.601280	9.962288	9.638992	10.361008	10.037712	10.398720	28
33	9.601570	9.962233	9.639337	10.360663	10.037767	10.398430	27
34	9.601860	9.962178	9.639682	10.360318	10.037822	10.398140	26
35	9.602149	9.962123	9.640027	10.359973	10.037877	10.397851	25
36	9.602439	9.962067	9.640371	10.359629	10.037933	10.397561	24
37	9.602728	9.962012	9.640716	10.359284	10.037988	10.397272	23
38	9.603017	9.961957	9.641060	10.358940	10.038043	10.396983	22
39	9.603305	9.961902	9.641404	10.358596	10.038098	10.396695	21
40	9.603594	9.961846	9.641747	10.358253	10.038154	10.396406	20
41	9.603882	9.961791	9.642091	10.357909	10.038209	10.396118	19
42	9.604170	9.961735	9.642434	10.357566	10.038265	10.395830	18
43	9.604457	9.961680	9.642777	10.357223	10.038320	10.395543	17
44	9.604745	9.961624	9.643120	10.356880	10.038376	10.395255	16
45	9.605032	9.961569	9.643463	10.356537	10.038431	10.394968	15
46	9.605319	9.961513	9.643806	10.356194	10.038487	10.394681	14
47	9.605606	9.961458	9.644148	10.355852	10.038542	10.394394	13
48	9.605892	9.961402	9.644490	10.355510	10.038598	10.394108	12
49	9.606179	9.961346	9.644832	10.355168	10.038654	10.393821	11
50	9.606465	9.961290	9.645174	10.354826	10.038710	10.393535	10
51	9.606751	9.961235	9.645516	10.354484	10.038765	10.393249	9
52	9.607036	9.961179	9.645857	10.354143	10.038821	10.392964	8
53	9.607322	9.961123	9.646199	10.353801	10.038877	10.392678	7
54	9.607607	9.961067	9.646540	10.353460	10.038933	10.392393	6
55	9.607892	9.961011	9.646881	10.353119	10.038989	10.392108	5
56	9.608176	9.960955	9.647222	10.352778	10.039045	10.391824	4
57	9.608461	9.960899	9 647562	10.352438	10.039101	10.391539	3
58	9.608745	9.960843	9.647903	10.352097	10.039157	10.391255	2
59	9.609029	9.960786	9.648243	10.351757	10.039214	10.390971	1
60	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687	0
		Sine		Tangent		Secant	Minutes

66 Degrees.

24 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.609313	9.960730	9.648583	10.351417	10.039270	10.390687	60
1	9.609597	9.960674	9.648923	10.351077	10.039326	10.390403	59
2	9.609880	9.960618	9 649263	10.350737	10.039382	10.390120	58
3	9.610163	9.960561	9 649602	10.350398	10.039439	10.389837	57
4	9.610446	9.960505	9.649942	10.350058	10.039495	10.389554	56
5	9.610729	9.960448	9.650281	10.349719	10.039552	10.389271	55
6	9 611012	9.960392	9.650620	10.349380	10.039608	10.388988	54
7	9.611294	9.960335	9.650959	10.349041	10.039665	10.388706	53
8	9.611576	9.960279	9.651297	10.348703	10.039721	10.388424	52
9	9 611858	9 960222	9.651636	10.348364	10.039778	10 388142	51
10	9.612140	9.960166	9.651974	10.348026	10.039834	10.387860	50
11	9 612421	9.960109	9.652312	10.347688	10.039891	10.387579	49
12	9.612702	9.960052	9.652650	10.347350	10.039948	10.387298	48
13	9.612983	9.959995	9.652988	10.347012	10.040005	10.387017	47
14	9.613264	9.959938	9.653326	10.346674	10.040062	10.386736	46
15	9.613545	9.959882	9.653663	10.346337	10.040118	10.386455	45
16	9.613825	9.959825	9.654000	10.346000	10 040175	10.386175	44
17	9.614105	9.959768	9.654337	10.345663	10.040232	10 385895	43
18	9.614385	9.959711	9.654674	10.345326	10.040289	10.385615	42
19	9.614665	9.959653	9.655011	10.344989	10.040347	10.385335	41
20	9.614944	9.959596	9.655348	10.344652	10.040404	10.385056	40
21	9.615223	9.959539	9.655684	10.344316	10.040461	10.384777	39
22	9.615502	9 959482	9.656020	10.343980	10.040518	10.384498	38
23	9.615781	9.959425	9.656356	10.343644	10.040575	10.384219	37
24	9 616060	9 959368	9.656692	10.343308	10.040632	10.383940	36
25	9.616338	9.959310	9.657028	10.342972	10.040690	10.383662	35
26	9.616616	9.959253	9.657364	10.342636	10.040747	10.383384	34
27	9.616894	9.959195	9 657699	10.342301	10 040805	10.383106	33
28	9.617172	9.959138	9.658034	10.341966	10.040862	10.382828	32
29	9.617450	9.959081	9.658369	10.341631	10.040919	10.382550	31
30	9.617727	9.959023	9.658704	10.341296	10.040977	10.382273	30
		Sine		Tangent		Secant	Minutes

65 Degrees.

24 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.617727	9.959023	9.658704	10.341296	10.040977	10.382273	30
31	9.618004	9.958965	9.659039	10.340961	10.041035	10.381996	29
32	9.618281	9.958908	9.659373	10.340627	10.041092	10.381719	28
33	9.618558	9.958850	9.659708	10.340292	10.041150	10.381442	27
34	9.618834	9.958792	9.660042	10.339958	10.041208	10.381166	26
35	9.619110	9.958734	9.660376	10.339624	10.041266	10.380890	25
36	9.619386	9.958677	9.660710	10.339290	10.041323	10.380614	24
37	9.619662	9.958619	9.661043	10.338957	10.041381	10.380338	23
38	9.619938	9.958561	9.661377	10.338623	10.041439	10.380062	22
39	9.620213	9.958503	9.661710	10.338290	10.041497	10.379787	21
40	9.620488	9.958445	9.662043	10.337957	10.041555	10.379512	20
41	9.620763	9.958387	9.662376	10.337624	10.041613	10.379237	19
42	9.621038	9.958329	9.662709	10.337291	10.041671	10.378962	18
43	9.621313	9.958271	9.663042	10.336958	10.041729	10.378687	17
44	9.621587	9.958212	9.663375	10.336225	10.041788	10.378413	16
45	9.621861	9.958154	9.663707	10.336293	10.041846	10.378139	15
46	9.622135	9.958096	9.664039	10.335961	10.041904	10.377865	14
47	9.622409	9.958038	9.664371	10.335629	10.041962	10.377591	13
48	9.622682	9.957979	9.664703	10.335297	10.042021	10.377318	12
49	9.622956	9.957921	9.665035	10.334965	10.042079	10.377044	11
50	9.623229	9.957863	9.665366	10.334634	10.042137	10.376771	10
51	9.623502	9.957804	9.665697	10.334303	10.042196	10.376498	9
52	9.623774	9.957746	9.666029	10.333971	10.042254	10.376226	8
53	9.624047	9.957687	9.666360	10.333640	10.042313	10.375953	7
54	9.624319	9.957628	9.666691	10.333309	10.042372	10.375681	6
55	9.624591	9.957570	9.667021	10.332979	10.042430	10.375409	5
56	9.624863	9.957511	9.667352	10.332648	10.042489	10.375137	4
57	9.625135	9.957452	9.667682	10.332318	10.042548	10.374865	3
58	9.625406	9.957393	9.668013	10.331987	10.042607	10.374594	2
59	9.625677	9.957335	9.668343	10.331657	10.042665	10.374323	1
60	9.625948	9.957276	9.668672	10.331328	10.042724	10.374052	0
		Sine		Tangent		Secant	Minutes

65 Degrees.

25 Degrees.

Minutes	Sine		Tangen		Secant		
0	9.625948	9.957276	9.668672	10.331328	10.042724	10.374052	60
1	9.626219	9.957217	9.669002	10.330998	10.042783	10.373781	59
2	9.626490	9.957158	9.669332	10.330668	10.042842	10.373510	58
3	9.626760	9.957099	9.669661	10.330339	10.042901	10.373240	57
4	9.627030	9.957040	9.669991	10.330009	10.042960	10.372970	56
5	9.627300	9.956981	9.670320	10.329680	10.043019	10.372700	55
6	9.627570	9.956922	9.670649	10.329351	10.043078	10.372430	54
7	9.627840	9.956862	9.670977	10.329023	10.043138	10.372160	53
8	9.628109	9.956803	9.671306	10.328694	10.043197	10.371891	52
9	9.628378	9.956744	9.671634	10.328366	10.043256	10.371622	51
10	9.628647	9.956684	9.671963	10.328037	10.043316	10.371353	50
11	9.628916	9.956625	9.672291	10.327709	10.043375	10.371084	49
12	9.629184	9.956566	9.672619	10.327381	10.043434	10.370816	48
13	9.629453	9.956506	9.672947	10.327053	10.043494	10.370547	47
14	9.629721	9.956447	9.673274	10.326726	10.043553	10.370279	46
15	9.629989	9.956387	9.673602	10.326398	10.043613	10.370011	45
16	9.630257	9.956327	9.673929	10.326071	10 043673	10.369743	44
17	9.630524	9.956268	9.674257	10.325743	10.043732	10.369476	43
18	9.630792	9.956208	9.674584	10.325416	10.043792	10.369208	42
19	9.631059	9.956148	9.674910	10.325090	10.043852	10.368941	41
20	9.631326	9.956089	9.675237	10.324763	10.043911	10.368674	40
21	9.631593	9.956029	9.675564	10.324436	10.043971	10.368407	39
22	9.631859	9 955969	9.675890	10.324110	10.044031	10.368141	38
23	9.632126	9.955909	9.676216	10.323784	10.044091	10.367874	37
24	9.632392	9.955849	9.676543	10.323457	10.044151	10.367608	36
25	9.632658	9.955789	9.676869	10.323131	10.044211	10.367342	35
26	9.632923	9.955729	9.677194	10.322806	10.044271	10.367077	34
27	9.633189	9.955669	9 677520	10.322480	10.044331	10.366811	33
28	9.633454	9.955609	9.677846	10.322154	10.044391	10.366546	32
29	9.633719	9.955548	9.678171	10.321829	10.044452	10.366281	31
30	9.633984	9.955488	9.678496	10.321504	10.044512	10.366016	30
		Sine		Tangent		Secant	Minutes

64 Degrees.

25 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.633984	9.955488	9.678496	10.321504	10.044512	10.366016	30
31	9.634249	9.955428	9.678821	10.321179	10.044572	10.365751	29
32	9.634514	9.955368	9.679146	10.320854	10.044632	10.365486	28
33	9.634778	9.955307	9.679471	10.320529	10.044693	10.365222	27
34	9.635042	9.955247	9.679795	10.320205	10.044753	10.364958	26
35	9.635306	9.955186	9.680120	10.319880	10.044814	10.364694	25
36	9.635570	9.955126	9.680444	10.319556	10.044874	10.364430	24
37	9.635833	9.955065	9.680768	10.319232	10.044935	10.364167	23
38	9.636097	9.955005	9.681092	10.318908	10.044995	10.363903	22
39	9.636360	9.954944	9.681416	10.318584	10.045056	10.363640	21
40	9.636623	9.954883	9.681740	10.318260	10.045117	10.363377	20
41	9.636886	9.954823	9.682063	10.317937	10.045177	10.363114	19
42	9.637148	9.954762	9.682386	10.317614	10.045238	10.362852	18
43	9.637411	9.954701	9.682710	10.317290	10.045299	10.362589	17
44	9.637673	9.954640	9.683033	10.316967	10.045360	10.362327	16
45	9.637935	9.954579	9.683356	10.316644	10.045421	10.362065	15
46	9.638197	9.954518	9.683678	10.316322	10.045482	10.361803	14
47	9.638458	9.954457	9.684001	10.315999	10.045543	10.361542	13
48	9.638720	9.954396	9.684324	10.315676	10.045604	10.361280	12
49	9.638981	9.954335	9.684646	10.315354	10.045665	10.361019	11
50	9.639242	9.954274	9.684968	10.315032	10.045726	10.360758	10
51	9.639503	9.954213	9.685290	10.314710	10.045787	10.360497	9
52	9.639764	9.954152	9.685612	10.314388	10.045848	10.360236	8
53	9.640024	9.954090	9.685934	10.314066	10.045910	10.359976	7
54	9.640284	9.954029	9.686255	10.313745	10.045971	10.359716	6
55	9.640544	9.953968	9.686577	10.313423	10.046032	10.359456	5
56	9.640804	9.953906	9.686898	10 313102	10.046094	10.359196	4
57	9.641064	9.953845	9.687219	10.312781	10.046155	10.358936	3
58	9.641323	9.953783	9.687540	10.312460	10.046217	10.358677	2
59	9.641583	9.953722	9.687861	10.312139	10.046278	10.358417	1
60	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158	0
		Sine		Tangent		Secant	Minutes

64 Degrees.

26 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.641842	9.953660	9.688182	10.311818	10.046340	10.358158	60
1	9.642101	9.953598	9.688502	10.311498	10.046402	10.357899	59
2	9.642360	9.953537	9.688823	10.311177	10.046463	10.357640	58
3	9.642618	9.953475	9.689143	10.310857	10.046525	10.357382	57
4	9.642876	9.953413	9.689463	10.310537	10.046587	10 357124	56
5	9.643135	9.953352	9.689783	10.310217	10.046648	10.356865	55
6	9.643393	9.953290	9.690103	10.309897	10.046710	10.356607	54
7	9.643650	9.953228	9 690423	10.309577	10.046772	10.356350	53
8	9.643908	9.953166	9.690742	10.309258	10.046834	10.356092	32
9	9.644165	9.953104	9.691062	10.308938	10.046896	10.355835	51
10	9.644423	9.953042	9.691381	10.308619	10.046958	10.355577	50
11	9.644680	9.952980	9.691700	10.308300	10.047020	10.355320	49
12	9 644937	9.952917	9.692019	10.307981	10.047083	10.355063	48
13	9.645193	9.952855	9.692338	10.307662	10.047145	10.354807	47
14	9.645450	9.952793	9 692657	10.307343	10.047207	10.354550	46
15	9.645706	9.952731	9.692975	10.307025	10.047269	10.354294	45
16	9 645962	9.952669	9.693293	10.306707	10.047331	10.354038	44
17	9.646218	9.952606	9.693612	10.306388	10.047394	10.353782	43
18	9.646474	9.952544	9.693930	10.306070	10.047456	10.353526	42
19	9.646729	9.952481	9.694248	10.305752	10.047519	10.353271	41
20	9.646984	9.952419	9.694566	10.305434	10.047581	10.353016	40
21	9.647239	9.952356	9.694883	10.305117	10.047644	10.352761	39
22	9.647495	9.952294	9.695201	10.304799	10.047706	10.352505	38
23	9.647749	9.952231	9.695518	10.304482	10.047769	10.352251	37
24	9.648004	9.952168	9.695836	10.304164	10.047832	10.351996	36
25	9.648258	9.952105	9.696153	10.303847	10.047895	10.351742	35
26	9 648512	9.952043	9.696470	10.303530	10.047957	10.351488	34
27	9.648766	9.951980	9.696787	10.303213	10.048020	10.351234	33
28	9.649020	9.951917	9.697103	10.302897	10.048083	10.350980	32
29	9.649274	9.951854	9.697420	10.302580	10.048146	10.350726	31
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473	30
		Sine		Tangent		Secant	Minutes

63 Degrees.

26 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.649527	9.951791	9.697736	10.302264	10.048209	10.350473	30
31	9.649781	9.951728	9.698053	10.301947	10.048272	10.350219	29
32	9.650034	9.951665	9.698369	10.301631	10.048335	10.349966	28
33	9.650287	9.951602	9.698685	10.301315	10.048398	10.349713	27
34	9.650539	9.951539	9.699001	10.300999	10.048461	10.349461	26
35	9.650792	9.951476	9.699316	10.300684	10.048524	10.349208	25
36	9.651044	9.951412	9.699632	10.300368	10.048588	10.348956	24
37	9.651297	9.951349	9.699947	10.300053	10.048651	10.348703	23
38	9.651549	9.951286	9.700263	10.299737	10.048714	10.348451	22
39	9.651800	9.951222	9.700578	10.299422	10.048778	10.348200	21
40	9.652052	9.951159	9.700893	10.299107	10.048841	10.347948	20
41	9.652304	9.951096	9.701208	10.298792	10.048904	10.347696	19
42	9.652555	9.951032	9.701523	10.298477	10.048968	10.347445	18
43	9.652806	9.950968	9.701837	10.298163	10.049032	10.347194	17
44	9.653057	9.950905	9.702152	10.297848	10.049095	10.346943	16
45	9.653307	9.950841	9.702466	10.297534	10.049159	10.346693	15
46	9.653558	9.950778	9.702780	10.297220	10.049222	10.346442	14
47	9.653808	9.950714	9.703095	10.296905	10.049286	10.346192	13
48	9.654059	9.950650	9.703409	10.296591	10.049350	10.345941	12
49	9.654309	9.950586	9.703723	10.296277	10.049414	10.345691	11
50	9.654558	9.950522	9.704036	10.295964	10.049478	10.345442	10
51	9.654808	9.950458	9.704350	10.295650	10.049542	10.345192	9
52	9.655057	9.950394	9.704663	10.295337	10.049606	10.344943	8
53	9.655307	9.950330	9.704977	10.295023	10.049670	10.344693	7
54	9.655556	9.950266	9.705290	10.294710	10.049734	10.344444	6
55	9.655805	9.950202	9.705603	10.294397	10.049798	10.344195	5
56	9.656054	9.950138	9.705916	10.294084	10.049862	10.343946	4
57	9.656302	9.950074	9.706228	10.293772	10.049926	10.343698	3
58	9.656551	9.950009	9.706541	10.293459	10.049991	10.343449	2
59	9.656799	9.949945	9.706854	10.293146	10.050055	10.343201	1
60	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	0
		Sine		Tangent		Secant	Minutes

27 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.657047	9.949881	9.707166	10.292834	10.050119	10.342953	60
1	9.657295	9.949816	9.707478	10.292522	10.050184	10.342705	59
2	9.657542	9.949752	9.707790	10.292210	10.050248	10.342458	58
3	9.657790	9.949688	9.708102	10.291898	10.050312	10.342210	57
4	9.658037	9.949623	9.708414	10.291586	10.050377	10 341963	56
5	9.658284	9.949558	9.708726	10.291274	10.050442	10.341716	55
6	9.658531	9.949494	9.709037	10.290963	10.050506	10.341469	54
7	9.658778	9.949429	9.709349	10.290651	10.050571	10.341222	53
8	9.659025	9.949364	9.709660	10.290340	10.050636	10.340975	52
9	9.659271	9.949300	9.709971	10.290029	10.050700	10.340729	51
10	9.659517	9.949235	9.710282	10.289718	10.050765	10.340483	50
11	9.659763	9.949170	9.710593	10.289407	10.050830	10.340237	49
12	9.660009	9.949105	9.710904	10.289096	10.050895	10.339991	48
13	9.660255	9.949040	9.711215	10.288785	10.050960	10.339745	47
14	9.660500	9.948975	9.711525	10.288475	10.051025	10.339500	46
15	9.660746	9.948910	9.711836	10.288164	10.051090	10.339254	45
16	9.660991	9.948845	9.712146	10.287854	10.051155	10.339009	44
17	9.661236	9.948780	9.712456	10.287544	10.051220	10.338764	43
18	9.661481	9.948715	9.712766	10.287234	10.051285	10.338519	42
19	9.661726	9.948649	9.713076	10.286924	10.051351	10.338274	41
20	9.661970	9.948584	9.713386	10.286614	10.051416	10.338030	40
21	9.662214	9.948519	9.713696	10.286304	10.051481	10.337786	39
22	9.662459	9.948453	9.714005	10.285995	10.051547	10.337541	38
23	9.662703	9.948388	9.714314	10.285686	10.051612	10.337297	37
24	9.662946	9.948323	9.714624	10.285376	10.051677	10.337054	36
25	9.663190	9.948257	9.714933	10.285067	10.051743	10.336810	35
26	9.663433	9.948192	9.715242	10.284758	10.051808	10.336567	34
27	9.663677	9.948126	9.715551	10.284449	10.051874	10.336323	33
28	9.663920	9.948060	9.715859	10.284141	10.051940	10.336080	32
29	9.664163	9.947995	9.716168	10.283832	10.052005	10.335837	31
30	9.664406	9.947929	9.716477	10.283523	10.052071	10.335594	30
		Sine		Tangent		Secant	Minutes

62 Degrees.

27 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.664406	9.947929	9.716477	10.283523	10.052071	10.335594	30
31	9.664648	9.947863	9.716785	10.283215	10.052137	10.335352	29
32	9.664891	9.947797	9.717093	10.282907	10.052203	10.335109	28
33	9.665133	9.947731	9.717401	10.282599	10.052269	10.334867	27
34	9.665375	9.947665	9.717709	10.282291	10.052335	10.334625	26
35	9.665617	9.947599	9.718017	10.281983	10.052401	10.334383	25
36	9.665859	9.947533	9.718325	10.281675	10.052467	10.334141	24
37	9.666100	9.947467	9.718633	10.281367	10.052533	10.333900	23
38	9.666341	9.947401	9.718940	10.281060	10.052599	10.333659	22
39	9.666583	9.947335	9.719248	10.280752	10.052665	10.333417	21
40	9.666824	9.947269	9.719555	10.280445	10.052731	10.333176	20
41	9.667065	9.947203	9.719862	10.280138	10.052797	10.332935	19
42	9.667305	9.947136	9.720169	10.279831	10.052864	10.332695	18
43	9.667546	9.947070	9.720476	10.279524	10.052930	10.332454	17
44	9.667786	9 947004	9.720783	10.279217	10.052996	10.332214	16
45	9.668026	9.946937	9.721089	10.278911	10.053063	10.331974	15
46	9.668266	9.946871	9.721396	10.278604	10.053129	10.331734	14
47	9.668506	9.946804	9.721702	10.278298	10.053196	10.331494	13
48	9.668746	9.946738	9.722008	10.277992	10.053262	10.331254	12
49	9.668986	9.946671	9.722315	10.277685	10.053329	10.331014	11
50	9.669225	9.946604	9.722621	10.277379	10.053396	10.330775	10
51	9.669464	9.946538	9.722927	10.277073	10.053462	10.330536	9
52	9.669703	9.946471	9.723232	10.276768	10.053529	10.330297	8
53	9.669942	9.946404	9.723538	10.276462	10.053596	10.330058	7
54	9.670181	9.946337	9.723844	10.276156	10.053663	10.329819	6
55	9.670419	9.946270	9.724149	10.275851	10.053730	10.329581	5
56	9.670658	9.946203	9.724454	10.275546	10.053797	10.329342	4
57	9.670896	9.946136	9.724759	10.275241	10.053864	10.329104	3
58	9.671134	9.946069	9.725065	10.274935	10.053931	10.328866	2
59	9.671372	9.946002	9.725369	10.274631	10.053998	10.328628	1
60	9.671609	9.945935	9.725674	10.274326	10.053065	10.328391	0
		Sine		Tangent		Secant	Minutes

62 Degrees.

28 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.671609	9.945935	9.725674	10.274326	10.054065	10.328391	60
1	9.671847	9.945868	9.725979	10.274021	10.054132	10.328153	59
2	9.672084	9.945801	9.726284	10.273716	10.054199	10.327916	58
3	9.672321	9.945733	9.726588	10.273412	10.054267	10.327679	57
4	9.672558	9.945666	9.726893	10.273107	10.054334	10.327442	56
5	9.672795	9.945598	9.727197	10.272803	10.054402	10.327205	55
6	9 673032	9.945531	9.727501	10.272499	10.054469	10.326968	54
7	9.673268	9.945464	9 727805	10.272195	10.054536	10.326732	53
8	9.673505	9 945396	9.728109	10.271891	10.054604	10.326495	52
9	9.673741	9.945328	9 728412	10.271588	10.054672	10.326259	51
10	9.673977	9.945261	9.728716	10.271284	10 054739	10.326023	50
11	9.674213	9.945193	9 729020	10.270980	10.054807	10.325787	49
12	9.674448	9.945126	9.729323	10.270677	10.054874	10.325552	48
13	9.674684	9.945058	9.729626	10.270374	10.054942	10.325316	47
14	9.674919	9 944990	9.729929	10.270071	10.055010	10.325081	46
15	9.675155	9.944922	9 730233	10.269767	10.055078	10.324845	45
16	9.675390	9.944854	9.730535	10.269465	10.055146	10.324610	44
17	9.675625	9.944786	9.730838	10.269162	10.055214	10.324375	43
18	9.675859	9.944718	9.731141	10.268859	10.055282	10.324141	42
19	9.676094	9.944650	9.731444	10.268556	10 055350	10.323906	41
20	9.676328	9.944582	9.731746	10.268254	10.055418	10.323672	40
21	9.676562	9.944514	9.732048	10.267952	10.055486	10.323438	39
22	9.676796	9.944446	9 732351	10.267649	10.055554	10.323204	38
23	9.677030	9.944377	9.732653	10.267347	10.055623	10.322970	37
24	9.677264	9.944309	9.732955	10.267045	10.055691	10.322736	36
25	9.677498	9.944241	9.733257	10.266743	10 055759	10.322502	35
26	9.677731	9.944173	9.733558	10.266442	10.055827	10.322269	34
27	9.677964	9.944104	9.733860	10.266140	10.055896	10.322036	33
28	9.678197	9.944036	9.734162	10.265838	10.055964	10.321803	32
29	9.678430	9.943967	9.734463	10.265537	10.056033	10.321570	31
30	9.678663	9.943898	9.734764	10.265236	10.056102	10.321337	30
		Sine		Tangent		Secant	Minutes

61 Degrees.

28 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.678663	9.943898	9.734764	10.265236	10.056102	10.321337	30
31	9.678895	9.943830	9.735066	10.264934	10.056107	10.321105	29
32	9.679128	9.943761	9.735367	10.264633	10.056239	10.320872	28
33	9.679360	9.943693	9.735668	10.264332	10.056307	10.320640	27
34	9.679592	9.943624	9.735968	10.264032	10.056376	10.320408	26
35	9.679824	9.943555	9.736269	10.263731	10.056445	10.320176	25
36	9.680056	9.943486	9.736570	10.263430	10.056514	10.319944	24
37	9.680288	9.943417	9.736871	10.263129	10.056583	10.319712	23
38	9.680519	9.943348	9.737171	10.262829	10.056652	10.319481	22
39	9.680750	9.943279	9.737471	10.262529	10.056721	10.319250	21
40	9.680982	9.943210	9.737771	10.262229	10.056790	10.319018	20
41	9.681213	9.943141	9.738071	10.261929	10.056859	10.318787	19
42	9.681443	9.943072	9.738371	10.261629	10.056928	10.318557	18
43	9.681674	9.943003	9.738671	10.261329	10.056997	10.318326	17
44	9.681905	9.942934	9.738971	10.261029	10.057066	10.318095	16
45	9.682135	9.942864	9.739271	10.260729	10.057136	10.317865	15
46	9.682365	9.942795	9.739570	10.260430	10.057205	10.317635	14
47	9.682595	9.942725	9.739870	10.260130	10.057275	10.317405	13
48	9.682825	9.942656	9.740169	10.259831	10.057344	10.317175	12
49	9.683055	9.942587	9.740468	10.259532	10.057413	10.316945	11
50	9.683284	9.942517	9.740767	10.259233	10.057483	10.316716	10
51	9.683514	9.942448	9.741066	10.258934	10.057552	10.316486	9
52	9.683743	9.942378	9.741365	10.258635	10.057622	10.316257	8
53	9.683972	9.942308	9.741664	10.258336	10.057692	10.316028	7
54	9.684201	9.942239	9.741962	10.258038	10.057761	10.315799	6
55	9.684430	9.942169	9.742261	10.257739	10.057831	10.315570	5
56	9.684658	9.942099	9.742559	10.257441	10.057901	10.315342	4
57	9.684887	9.942029	9.742858	10.257142	10.057971	10.315113	3
58	9.685115	9.941959	9.743156	10.256844	10.058041	10.314885	2
59	9.685343	9.941889	9.743454	10.256546	10.058111	10.314657	1
60	9.685571	9.941819	9.743752	10.256248	10.058181	10.314429	0
		Sine		Tangent		Secant	Minutes

61 Degrees.

29 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.685571	9.941819	9.743752	10.256248	10.058181	10.314429	60
1	9.685799	9.941749	9.744050	10.255950	10.058251	10.314201	59
2	9.686027	9.941679	9.744348	10.255652	10.058321	10.313973	58
3	9.686254	9.941609	9.744645	10.255355	10.058391	10.313746	57
4	9.686482	9.941539	9.744943	10.255057	10.058461	10.313518	56
5	9 686709	9.941468	9.745240	10.254760	10.058532	10.313291	55
6	9.686936	9.941398	9.745538	10.254462	10.058602	10.313064	54
7	9.687163	9.941328	9.745835	10.254165	10.058672	10.312837	53
8	9.687389	9.941258	9.746132	10.253868	10.058742	10.312611	52
9	9.687616	9.941187	9.746429	10.253571	10.058813	10.312384	51
10	9.687843	9.941117	9.746726	10.253274	10 058883	10.312157	50
11	9.688069	9.941046	9.747023	10.252977	10.058954	10.311931	49
12	9.688295	9.940975	9.747319	10.252681	10.059025	10.311705	48
13	9.688521	9.940905	9.747616	10.252384	10.059095	10.311479	47
14	9.688747	9 940834	9.747912	10.252088	10.059166	10.311253	46
15	9.688972	9.940763	9.748209	10.251791	10.059237	10.311028	45
16	9.689198	9.940693	9.748505	10.251495	10.059307	10.310802	44
17	9.689423	9.940622	9.748801	10.251199	10.059378	10.310577	43
18	9.689648	9.940551	9.749097	10.250903	10.059449	10.310352	42
19	9.689873	9.940480	9.749393	10.250607	10 059520	10.310127	41
20	9.690098	9.940409	9.749689	10.250311	10.059591	10.309902	40
21	9.690323	9.940338	9.749985	10.250015	10.059662	10.309677	39
22	9.690548	9.940267	9 750281	10.249719	10.059733	10.309452	38
23	9.690772	9.940196	9.750576	10.249424	10.059804	10.309228	37
24	9.690996	9.940125	9.750872	10.249128	10.059875	10.309004	36
25	9 691220	9.940053	9.751167	10.248833	10 059947	10.308780	35
26	9.691444	9.939982	9.751462	10.248538	10.060018	10.308556	34
27	9.691668	9.939911	9.751757	10.248243	10.060089	10.308332	33
28	9.691892	9.939840	9.752052	10.247948	10.060160	10.308108	32
29	9.692115	9.939768	9.752347	10.247653	10.060232	10.307885	31
30	9.692339	9.939697	9.752642	10.247358	10.060303	10.307661	30
		Sine		Tangent		Secant	Minutes

60 Degrees.

29 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.692339	9.939697	9.752642	10.247358	10.060303	10.307661	30
31	9.692562	9.939625	9.752937	10.247063	10.060375	10.307438	29
32	9.692785	9.939554	9.753231	10.246769	10.060446	10.307215	28
33	9.693009	9.939482	9.753526	10.246474	10.060518	10.306991	27
34	9.693231	9.939410	9.753820	10.246180	10.060590	10.306769	26
35	9.693453	9.939339	9.754115	10.245885	10.060661	10.306547	25
36	9.693676	9.939267	9.754409	10.245591	10.060733	10.306324	24
37	9.693898	9.939195	9.754703	10.245297	10.060805	10.306102	23
38	9.694120	9.939123	9.754997	10.245003	10.060877	10.305880	22
39	9.694342	9.939051	9.755291	10.244709	10.060949	10.305658	21
40	9.694564	9.938980	9.755585	10.244415	10.061020	10.305436	20
41	9.694786	9.938908	9.755878	10.244122	10.061092	10.305214	19
42	9.695007	9.938836	9.756172	10.243828	10.061164	10.304993	18
43	9.695229	9.938763	9.756465	10.243535	10.061237	10.304771	17
44	9.695450	9.938691	9.756759	10.243241	10.061309	10.304550	16
45	9.695671	9.938619	9.757052	10.242948	10.061381	10.304329	15
46	9.695892	9.938547	9.757345	10.242655	10.061453	10.304108	14
47	9.696113	9.938475	9.757638	10.242362	10.061525	10.303887	13
48	9.696334	9.938402	9.757931	10.242069	10.061598	10.303666	12
49	9.696554	9.938330	9.758224	10 241776	10.061670	10.303446	11
50	9 696774	9.938258	9.758517	10.241483	10.061742	10.303226	10
51	9.696995	9.938185	9.758810	10.241190	10.061815	10.303005	9
52	9.697215	9.938113	9.759102	10.240898	10.061887	10.302785	8
53	9.697435	9.938040	9.759395	10.240605	10.061960	10.302565	7
54	9.697654	9.937967	9.759687	10.240313	10.062033	10.302346	6
55	9.697874	9.937895	9.759979	10.240021	10.062105	10.302126	5
56	9.698094	9.937822	9.760272	10.239728	10.062178	10.301906	4
57	9.698313	9.937749	9 760564	10.239436	10.062251	10.301687	3
58	9.698532	9.937676	9.760856	10.239144	10 062324	10.301468	2
59	9.698751	9.937603	9.761148	10.238852	10.062397	10.301249	1
60	9.698970	9.937531	9.761439	10.238561	10.062469	10.301030	0
		Sine		Tangent		Secant	Minutes

60 Degrees.

30 Degrees.

Minutes	Sine		Tangen		Secant		
0	9.698970	9.937531	9.761439	10.238501	10.062469	10.301030	60
1	9.699189	9.937458	9.761731	10.238269	10.062541	10.300811	59
2	9.699407	9.937385	9.762023	10.237977	10.062615	10.300593	58
3	9.699626	9.937312	9.762314	10.237686	10.062688	10.300374	57
4	9.699844	9.937238	9.762606	10.237394	10.062762	10.300156	56
5	9.700062	9.937165	9.762897	10.237103	10.062835	10.299938	55
6	9.700280	9.937092	9.763188	10.236812	10.062908	10.299720	54
7	9.700498	9.937019	9.763479	10.236521	10.062981	10.299502	53
8	9.700716	9.936946	9.763770	10.236230	10.063054	10.299284	52
9	9.700933	9.936872	9.764061	10.235939	10.063128	10.299067	51
10	9.701151	9.936799	9.764352	10.235648	10.063201	10.298849	50
11	9.701368	9.936725	9.764643	10.235357	10.063275	10.298632	49
12	9.701585	9.936652	9.764933	10.235067	10.063348	10.298415	48
13	9.701802	9.936578	9.765224	10.234776	10.063422	10.298198	47
14	9.702019	9.936505	9.765514	10.234486	10.063495	10.297981	46
15	9.702236	9.936431	9.765805	10.234195	10.063569	10.297764	45
16	9.702452	9.936357	9.766095	10.233905	10.063643	10.297548	44
17	9.702669	9.936284	9.766385	10.233615	10.063716	10.297331	43
18	9.702885	9.936210	9.766675	10.233325	10.063790	10.297115	42
19	9.703101	9.936136	9.766965	10.233035	10.063864	10.296899	41
20	9.703317	9.936062	9.767255	10.232745	10.063938	10.296683	40
21	9.703533	9.935988	9.767545	10.232455	10.064012	10.296467	39
22	9.703749	9.935914	9.767834	10.232166	10.064086	10.296251	38
23	9.703964	9.935840	9.768124	10.231876	10.064160	10.296036	37
24	9.704179	9.935766	9.768413	10.231587	10.064234	10.295821	36
25	9.704395	9.935692	9.768703	10.231297	10.064308	10.295605	35
26	9.704610	9.935618	9.768992	10.231008	10.064382	10.295390	34
27	9.704825	9.935543	9.769281	10.230719	10.064457	10.295175	33
28	9.705040	9.935469	9.769570	10.230430	10.064531	10.294960	32
29	9.705254	9.935395	9.769860	10.230140	10.064605	10.294746	31
30	9.705469	9.935320	9.770148	10.229852	10.064680	10.294531	30
		Sine		Tangent		Secant	Minutes

59 Degrees.

30 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.705469	9.935320	9.770148	10.229852	10.064680	10.294531	30
31	9.705683	9.935246	9.770437	10.229563	10.064754	10.294317	29
32	9.705897	9.935171	9.770726	10.229274	10.064829	10.294103	28
33	9.706112	9.935097	9.771015	10.228985	10.064903	10.293888	27
34	9.706326	9.935022	9.771303	10.228697	10.064978	10.293674	26
35	9.706539	9.934948	9.771592	10.228408	10.065052	10.293461	25
36	9.706753	9.934873	9.771880	10.228120	10.065127	10.293247	24
37	9.706967	9.934798	9.772168	10.227832	10.065202	10.293033	23
38	9.707180	9.934723	9.772457	10.227543	10.065277	10.292820	22
39	9.707393	9.934649	9.772745	10.227255	10.065351	10.292607	21
40	9.707606	9.934574	9.773033	10.226967	10.065426	10.292394	20
41	9.707819	9.934499	9.773321	10.226679	10.065501	10.292181	19
42	9.708032	9.934424	9.773608	10.226392	10.065576	10.291968	18
43	9.708245	9.934349	9.773896	10.226104	10.065651	10.291755	17
44	9.708457	9.934274	9.774184	10.225816	10.065726	10.291543	16
45	9.708670	9.934199	9.774471	10.225529	10.065801	10.291330	15
46	9.708882	9.934123	9.774759	10.225241	10.065877	10.291118	14
47	9.709094	9.934048	9.775046	10.224954	10.065952	10.290906	13
48	9.709306	9.933973	9.775333	10.224667	10.066027	10.290694	12
49	9.709518	9.933898	9.775621	10 224379	10.066102	10.290482	11
50	9.709730	9.933822	9.775908	10.224092	10.066178	10.290270	10
51	9.709941	9.933747	9.776195	10.223805	10.066253	10.290059	9
52	9.710153	9.933671	9.776482	10.223518	10.066329	10.289847	8
53	9.710364	9.933596	9.776769	10.223231	10.066404	10.289636	7
54	9.710575	9.933520	9.777055	10.222945	10.066480	10.289425	6
55	9.710786	9.933444	9.777342	10.222658	10.066556	10.289214	5
56	9.710997	9.933369	9.777628	10.222372	10.066631	10.289003	4
57	9.711208	9.933293	9 777915	10.222085	10.066707	10.288792	3
58	9.711419	9.933217	9.778201	10.221799	10 066783	10.288581	2
59	9.711629	9.933141	9.778487	10.221513	10.066859	10.288371	1
60	9.711839	9.933066	9.778774	10.221226	10.066934	10 288161	0
		Sine		Tangent		Secant	Minutes

59 Degrees.

31 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.711839	9.933066	9.778774	10.221226	10.066934	10.288161	60
1	9.712049	9.932990	9.779060	10.220940	10.067010	10.287951	59
2	9.712259	9.932914	9 779346	10.220654	10.067086	10.287741	58
3	9.712469	9.932838	9.779632	10.220368	10.067162	10.287531	57
4	9.712679	9.932762	9.779918	10.220082	10.067238	10.287321	56
5	9.712889	9.932685	9.780203	10.219797	10.067315	10.287111	55
6	9.713098	9.932609	9.780489	10.219511	10.067391	10.286902	54
7	9.713308	9.932533	9.780775	10.219225	10.067467	10.286692	53
8	9.713517	9.932457	9.781060	10.218940	10.067543	10.286483	52
9	9.713726	9 932380	9.781346	10.218654	10.067620	10 286274	51
10	9.713935	9.932304	9.781631	10.218369	10.067696	10.286065	50
11	9.714144	9.932228	9.781916	10.218084	10.067772	10.285856	49
12	9.714352	9.932151	9.782201	10.217799	10.067849	10.285648	48
13	9.714561	9.932075	9.782486	10.217514	10.067925	10.285439	47
14	9.714769	9.931998	9.782771	10.217229	10.068002	10.285231	46
15	9.714978	9.931921	9.783056	10.216944	10.068079	10.285022	45
16	9.715186	9.931845	9.783341	10.216659	10 068155	10 284814	44
17	9.715394	9.931768	9.783626	10.216374	10.068232	10.284606	43
18	9.715601	9.931691	9.783910	10.216090	10.068309	10.284399	42
19	9.715809	9.931614	9.784195	10.215805	10.068386	10.284191	41
20	9.716017	9.931537	9.784479	10.215521	10.068463	10.283983	40
21	9.716224	9.931460	9.784764	10.215236	10.068540	10.283776	39
22	9.716432	9 931383	9.785048	10.214952	10.068617	10.283568	38
23	9.716639	9.931306	9.785332	10.214668	10.068694	10.283361	37
24	9.716846	9.931229	9.785616	10.214384	10.068771	10.283154	36
25	9.717053	9.931152	9.785900	10.214100	10.068848	10.282947	35
26	9.717259	9.931075	9.786184	10.213816	10.068925	10.282741	34
27	9.717466	9 930998	9.786468	10.213532	10.069002	10.282534	33
28	9.717672	9.930920	9.786752	10.213248	10.069080	10.282328	32
29	9.717879	9.930843	9.787036	10.212964	10.069157	10.282121	31
30	9.718085	9.930766	9.787319	10.212681	10.069234	10.281915	30
		Sine		Tangent		Secant	Minutes

58 Degrees.

31 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.718085	9.930766	9.787319	10.212681	10.069234	10.281915	30
31	9.718291	9.930688	9.787603	10.212397	10.069312	10.281709	29
32	9.718497	9.930611	9.787886	10.212114	10.069389	10.281503	28
33	9.718703	9.930533	9.788170	10.211830	10.069467	10.281297	27
34	9.718909	9.9304 6	9.788453	10.211547	10.069544	10.281091	26
35	9.719114	9.930378	9 788736	10.211264	10.069622	10.280886	25
36	9.719320	9.930300	9.789019	10.210981	10.069700	10.280680	24
37	9.719525	9.930223	9.789302	10.210698	10.069777	10.280475	23
38	9.719730	9.930145	9.789585	10.210415	10.069855	10.280270	22
39	9.719935	9.930067	9.789868	10.210132	10.069933	10.280065	21
40	9.720140	9.929989	9.790151	10.209849	10.070011	10.279860	20
41	9.720345	9.929911	9.790433	10.209567	10.070089	10.279655	19
42	9.720549	9.929833	9.790716	10 209284	10.070167	10.279451	18
43	9.720754	9.929755	9.790999	10.209001	10.070245	10.279246	17
44	9.720958	9.929677	9.791281	10.208719	10.070323	10.279042	16
45	9.721162	9.929599	9.791563	10.208437	10.070401	10.278838	15
46	9.721366	9.929521	9.791846	10.208154	10.070479	10.278634	14
47	9.721570	9.929442	9.792128	10.207872	10.070558	10.278430	13
48	9 721774	9.929364	9.792410	10.207590	10.070636	10.278226	12
49	9.721978	9.929286	9.792692	10.207308	10.070714	10.278022	11
50	9.722181	9.929207	9.792974	10.207026	10.070793	10.277819	10
51	9.722385	9.929129	9.793256	10.206744	10.070871	10.277615	9
52	9.722588	9.929050	9 793538	10.206462	10.070950	10.277412	8
53	9.722791	9.928972	9.793819	10.206181	10.071028	10.277209	7
54	9.722994	9.928893	9.794101	10.205899	10.071107	10.277006	6
55	9.723197	9.928814	9.794383	10.205617	10.071186	10.276803	5
56	9.723400	9.928736	9.794664	10.205336	10.071264	10.276600	4
57	9.723603	9,928657	9.794945	10.205055	10.071343	10.276397	3
58	9.723805	9.928578	9.795227	10.204773	10.071422	10.276195	2
59	9.724007	9.928499	9.795508	10.204492	10.071501	10.275993	1
60	9 724210	9.928420	9.795789	10.204211	10.071580	10 275790	0
		Sine		Tangent		Secant	Minutes

58 Degrees.

32 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.724210	9.928420	9.795789	10.204211	10.071580	10.275790	60
1	9.724412	9.928341	9.796070	10.203930	10.071659	10.275588	59
2	9.724614	9.928262	9.796351	10.203649	10.071738	10.275386	58
3	9.724816	9.928183	9.796632	10.203368	10.071817	10.275184	57
4	9.725017	9.928104	9.796913	10.203087	10.071896	10.274983	56
5	9.725219	9.928025	9.797194	10.202806	10.071975	10.274781	55
6	9.725420	9.927946	9.797474	10.202526	10.072054	10.274580	54
7	9.725622	9.927867	9.797755	10.202245	10.072133	10.274378	53
8	9.725823	9.927787	9.798036	10.201964	10.072213	10.274177	52
9	9.726024	9.927708	9.798316	10.201684	10.072292	10.273976	51
10	9.726225	9.927628	9.798596	10.201404	10.072372	10.273775	50
11	9.726426	9.927549	9.798877	10.201123	10.072451	10.273574	49
12	9.726626	9.927469	9.799157	10.200843	10.072531	10.273374	48
13	9.726827	9.927390	9.799437	10.200563	10.072610	10.273173	47
14	9.727027	9.927310	9.799717	10.200283	10.072690	10.272973	46
15	9.727228	9.927231	9.799997	10.200003	10.072769	10.272772	45
16	9.727428	9.927151	9.800277	10.199723	10.072849	10.272572	44
17	9.727628	9.927071	9.800557	10.199443	10.072929	10.272372	43
18	9.727828	9.926991	9.800836	10.199164	10.073009	10.272172	42
19	9.728027	9.926911	9.801116	10.198884	10.073089	10.271973	41
20	9.728227	9.926831	9.801396	10.198604	10.073169	10.271773	40
21	9.728427	9.926751	9.801675	10.198325	10.073249	10.271573	39
22	9.728626	9.926671	9.801955	10.198045	10.073329	10.271374	38
23	9.728825	9.926591	9.802234	10.197760	10.073409	10.271175	37
24	9.729024	9.926511	9.802513	10.197487	10.073489	10.270976	36
25	9.729223	9.926431	9.802792	10.197208	10.073569	10.270777	35
26	9.729422	9.926351	9.803072	10.196928	10.073649	10.270578	34
27	9.729621	9.926270	9.803351	10.196649	10.073730	10.270379	33
28	9.729816	9.926190	9.803630	10.196370	10.073810	10.270184	32
29	9.730018	9.926110	9.803908	10.196092	10.073890	10.269982	31
30	9.730216	9.926029	9.804187	10.195813	10.073971	10.269784	30
		Sine		Tangent		Secant	Minutes

57 Degrees.

32 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.730216	9.926029	9.804187	10.195813	10.073971	10.269784	30
31	9.730415	9.925949	9.804466	10.195534	10.074051	10.269585	29
32	9.730613	9.925868	9.804745	10.195255	10.074132	10.269387	28
33	9.730811	9.925787	9.805023	10.194977	10.074213	10.269189	27
34	9.731009	9.925707	9.805302	10.194698	10.074293	10.268991	26
35	9.731206	9.925626	9.805580	10.194420	10.074374	10.268794	25
36	9.731404	9.925545	9.805859	10.194141	10.074455	10.268596	24
37	9.731601	9.925465	9.806137	10.193863	10.074535	10.268399	23
38	9.731799	9.925384	9.806415	10.193585	10.074616	10.268201	22
39	9.731996	9.925303	9.806693	10.193307	10.074697	10.268004	21
40	9.732193	9.925222	9.806971	10.193029	10.074778	10.267807	20
41	9.732390	9.925141	9.807249	10.192751	10.074859	10.267610	19
42	9.732587	9.925060	9.807527	10.192473	10.074940	10.267413	18
43	9.732784	9.924979	9.807805	10.192195	10.075021	10.267216	17
44	9.732980	9.924897	9.808083	10.191917	10.075103	10.267020	16
45	9.733177	9.924816	9.808361	10.191639	10.075184	10.266823	15
46	9.733373	9.924735	9.808638	10.191362	10.075265	10.266627	14
47	9.733569	9.924653	9.808916	10.191084	10.075347	10.266431	13
48	9.733765	9.924572	9.809193	10.190807	10.075428	10.266235	12
49	9.733961	9.924491	9.809471	10.190529	10.075509	10.266039	11
50	9.734157	9.924409	9.809748	10.190252	10.075591	10.265843	10
51	9.734353	9.924328	9.810025	10.189975	10.075672	10.265647	9
52	9.734548	9.924246	9.810302	10.189698	10.075754	10.265452	8
53	9.734744	9.924164	9.810580	10.189420	10.075836	10.265256	7
54	9.734939	9.924083	9.810857	10.189143	10.075917	10.265061	6
55	9.735134	9.924001	9.811134	10.188866	10.075999	10.264866	5
56	9.735330	9.923919	9.811410	10.188590	10.076081	10.264670	4
57	9.735525	9.923837	9.811687	10.188313	10.076163	10.264475	3
58	9.735719	9.923755	9.811964	10.188036	10.076245	10.264281	2
59	9.735914	9.923673	9.812241	10.187759	10.076327	10.264086	1
60	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	0
		Sine		Tangent		Secant	Minutes

57 Degrees.

33 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.736109	9.923591	9.812517	10.187483	10.076409	10.263891	60
1	9.736303	9.923509	9.812794	10.187206	10.076491	10.263697	59
2	9.736498	9.923427	9.813070	10.186930	10.076573	10.263502	58
3	9.736692	9.923345	9.813347	10.186653	10.076655	10.263308	57
4	9.736886	9.923263	9.813623	10.186377	10.076737	10.263114	56
5	9.737080	9.923180	9.813899	10.186101	10.076820	10.262920	55
6	9.737274	9.923098	9.814175	10.185825	10.076902	10.262726	54
7	9.737467	9.923016	9.814452	10.185548	10.076984	10.262533	53
8	9.737661	9.922933	9.814728	10.185272	10.077067	10.262339	52
9	9.737855	9.922851	9.815004	10.184996	10.077149	10.262145	51
10	9.738048	9.922768	9.815279	10.184721	10.077232	10.261952	50
11	9.738241	9.922686	9.815555	10.184445	10.077314	10.261759	49
12	9.738434	9.922603	9.815831	10.184169	10.077397	10.261566	48
13	9.738627	9.922520	9.816107	10.183893	10.077480	10.261373	47
14	9.738820	9.922438	9.816382	10.183618	10.077562	10.261180	46
15	9.739013	9.922355	9.816658	10.183342	10.077645	10.260987	45
16	9.739205	9.922272	9.816933	10.183067	10.077728	10.260795	44
17	9.739398	9.922189	9.817209	10.182791	10.077811	10.260602	43
18	9.739590	9.922106	9.817484	10.182516	10.077894	10.260410	42
19	9.739783	9.922023	9.817759	10.182241	10.077977	10.260217	41
20	9.739975	9.921940	9.818035	10.181965	10.078060	10.260025	40
21	9.740167	9.921857	9.818310	10.181690	10.078143	10.259833	39
22	9.740359	9.921774	9.818585	10.181415	10.078226	10.259641	38
23	9.740550	9.921691	9.818860	10.181140	10.078309	10.259450	37
24	9.740742	9.921607	9.819135	10.180865	10.078393	10.259258	36
25	9.740934	9.921524	9.819410	10.180590	10.078476	10.259066	35
26	9.741125	9.921441	9.819684	10.180316	10.078559	10.258875	34
27	9.741316	9.921357	9.819959	10.180041	10.078643	10.258684	33
28	9.741507	9.921274	9.820234	10.179766	10.078726	10.258493	32
29	9.741699	9.921190	9.820508	10.179492	10.078810	10.258301	31
30	9.741889	9.921107	9.820783	10.179217	10.078893	10.258111	30
		Sine		Tangent		Secant	Minutes

56 Degrees.

33 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.741889	9.921107	9.820783	10.179217	10.078893	10.258111	30
31	9.742080	9.921023	9.821057	10.178943	10.078977	10.257920	29
32	9.742271	9.920939	9.821332	10.178668	10.079061	10.257729	28
33	9.742462	9.920855	9.821606	10.178394	10.079145	10.257538	27
34	9.742652	9.920772	9.821880	10.178120	10.079228	10.257348	26
35	9.742842	9.920688	9.822154	10.177846	10.079312	10.257158	25
36	9.743033	9.920604	9.822429	10.177571	10.079396	10.256967	24
37	9.743223	9.920520	9.822703	10.177297	10.079480	10.256777	23
38	9.743413	9.920436	9.822977	10.177023	10.079564	10.256587	22
39	9.743602	9.920352	9.823250	10.176750	10.079648	10.256398	21
40	9.743792	9.920268	9.823524	10.176476	10.079732	10.256208	20
41	9.743982	9.920184	9.823798	10.176202	10.079816	10.256018	19
42	9.744171	9.920099	9.824072	10.175928	10.079901	10.255829	18
43	9.744361	9.920015	9.824345	10.175655	10.079985	10.255639	17
44	9.744550	9.919931	9.824619	10.175381	10.080069	10.255450	16
45	9.744739	9.919846	9.824893	10.175107	10.080154	10.255261	15
46	9.744928	9.919762	9.825166	10.174834	10.080238	10.255072	14
47	9.745117	9.919677	9.825439	10.174561	10.080323	10.254883	13
48	9.745306	9.919593	9.825713	10.174287	10.080407	10.254694	12
49	9.745494	9.919508	9.825986	10.174014	10.080492	10.254506	11
50	9.745683	9.919424	9.826259	10.173741	10.080576	10.254317	10
51	9.745871	9.919339	9.826532	10.173468	10.080661	10.254129	9
52	9.746059	9.919254	9.826805	10.173195	10.080746	10.253941	8
53	9.746248	9.919169	9.827078	10.172922	10.080831	10.253752	7
54	9.746436	9.919084	9.827351	10.172649	10.080916	10.253564	6
55	9.746624	9.919000	9.827624	10.172376	10.081000	10.253376	5
56	9.746811	9.918915	9.827897	10.172103	10.081085	10.253189	4
57	9.746999	9.918830	9.828170	10.171830	10.081170	10.253001	3
58	9.747187	9.918744	9.828442	10.171558	10.081256	10.252813	2
59	9.747374	9.918659	9.828715	10.171285	10.081341	10.252626	1
60	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438	0
		Sine		Tangent		Secant	Minutes

56 Degrees.

34 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.747562	9.918574	9.828987	10.171013	10.081426	10.252438	60
1	9.747749	9.918489	9.829260	10.170740	10.081511	10.252251	59
2	9.747936	9.918404	9.829532	10.170468	10.081596	10.252064	58
3	9.748123	9.918318	9.829805	10.170195	10.081682	10.251877	57
4	9.748310	9.918233	9.830077	10.169923	10.081767	10.251690	56
5	9.748497	9.918147	9.830349	10.169651	10.081853	10.251503	55
6	9.748683	9.918062	9.830621	10.169379	10.081938	10.251317	54
7	9.748870	9.917976	9.830893	10.169107	10.082024	10.251130	53
8	9.749056	9.917891	9.831165	10.168835	10.082109	10.250944	52
9	9.749242	9.917805	9.831437	10.168563	10.082195	10.250758	51
10	9.749429	9.917719	9.831709	10.168291	10.082281	10.250571	50
11	9.749615	9.917634	9.831981	10.168019	10.082366	10.250385	49
12	9.749801	9.917548	9.832253	10.167747	10.082452	10.250199	48
13	9.749987	9.917462	9.832525	10.167475	10.082538	10.250013	47
14	9.750172	9.917376	9.832796	10.167204	10.082624	10.249828	46
15	9.750358	9.917290	9.833068	10.166932	10.082710	10.249642	45
16	9.750543	9.917204	9.833339	10.166661	10.082796	10.249457	44
17	9.750729	9.917118	9.833611	10.166389	10.082882	10.249271	43
18	9.750914	9.917032	9.833882	10.166118	10.082968	10.249086	42
19	9.751099	9.916945	9.834154	10.165846	10.083055	10.248901	41
20	9.751284	9.916859	9.834425	10.165575	10.083141	10.248716	40
21	9.751469	9.916773	9.834696	10.165304	10.083227	10.248531	39
22	9.751654	9.916687	9.834967	10.165033	10.083313	10.248346	38
23	9.751838	9.916600	9.835238	10.164762	10.083400	10.248162	37
24	9.752023	9.916514	9.835509	10.164491	10.083486	10.247977	36
25	9.752207	9.916427	9.835780	10.164220	10.083573	10.247793	35
26	9.752392	9.916341	9.836051	10.163949	10.083659	10.247608	34
27	9.752576	9.916254	9.836322	10.163678	10.083746	10.247424	33
28	9.752760	9.916167	9.836593	10.163407	10.083833	10.247240	32
29	9.752944	9.916080	9.836864	10.163136	10.083920	10.247056	31
30	9.753128	9.915994	9.837134	10.162866	10.084006	10.246872	30
		Sine		Tangent		Secant	Minutes

55 Degrees.

34 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.753128	9.915994	9.837134	10.162866	10.084006	10.246872	30
31	9.753312	9.915907	9.837405	10.162595	10.084093	10.246688	29
32	9.753495	9.915820	9.837675	10.162325	10.084180	10.246505	28
33	9.753679	9.915733	9.837946	10.162054	10.084267	10.246321	27
34	9.753862	9.915646	9.838216	10.161784	10.084354	10.246138	26
35	9.754046	9.915559	9.838487	10.161513	10.084441	10.245954	25
36	9.754229	9.915472	9.838757	10.161243	10.084528	10.245771	24
37	9.754412	9.915385	9.839027	10.160973	10.084615	10.245588	23
38	9.754595	9.915297	9.839297	10.160703	10.084703	10.245405	22
39	9.754778	9.915210	9.839568	10.160432	10.084790	10.245222	21
40	9.754960	9.915123	9.839838	10.160162	10.084877	10.245040	20
41	9.755143	9.915035	9.840108	10.159892	10.084965	10.244857	19
42	9.755326	9.914948	9.840378	10.159622	10.085052	10.244674	18
43	9.755508	9.914860	9.840647	10.159353	10.085140	10.244492	17
44	9.755690	9.914773	9.840917	10.159083	10.085227	10.244310	16
45	9.755872	9.914685	9.841187	10.158813	10.085315	10.244128	15
46	9.756054	9.914598	9.841457	10.158543	10.085402	10.243946	14
47	9.756236	9.914510	9.841726	10.158274	10.085490	10.243764	13
48	9.756418	9.914422	9.841996	10.158004	10.085578	10.243582	12
49	9.756600	9.914334	9.842266	10.157734	10.085666	10.243400	11
50	9.756781	9.914246	9.842535	10.157465	10.085754	10.243219	10
51	9.756963	9.914158	9.842805	10.157195	10.085842	10.243037	9
52	9.757144	9.914070	9.843074	10.156926	10.085930	10.242856	8
53	9.757326	9.913982	9.843343	10.156657	10.086018	10.242674	7
54	9.757507	9.913894	9.843612	10.156388	10.086106	10.242493	6
55	9.757688	9.913806	9.843882	10.156118	10.086194	10.242312	5
56	9.757869	9.913718	9.844151	10.155849	10.086282	10.242131	4
57	9.758049	9.913630	9.844420	10.155580	10.086370	10.241951	3
58	9.758230	9.913541	9.844689	10.155311	10.086459	10.241770	2
59	9.758411	9.913453	9.844958	10.155042	10.086547	10.241589	1
60	9.758591	9.913364	9.845227	10.154773	10.086636	10.241409	0
		Sine		Tangent		Secant	Minutes

55 Degrees.

35 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.758591	9.913364	9.845227	10.154773	10.086636	10.241409	60
1	9.758772	9.913276	9.845496	10.154504	10.086724	10.241228	59
2	9.758952	9.913187	9.845764	10.154236	10.086813	10.241048	58
3	9.759132	9.913099	9.846033	10.153967	10.086901	10.240868	57
4	9.759312	9.913010	9.846302	10.153698	10.086990	10.240688	56
5	9.759492	9.912921	9.846570	10.153430	10.087079	10.240508	55
6	9.759672	9.912833	9.846839	10.153161	10.087167	10.240328	54
7	9.759851	9.912744	9.847107	10.152893	10.087256	10.240149	53
8	9.760031	9.912655	9.847376	10.152624	10.087345	10.239969	52
9	9.760211	9.912566	9.847644	10.152356	10.087434	10.239789	51
10	9.769390	9.912477	9.847913	10.152087	10 087523	10.239610	50
11	9.760569	9.912388	9.848181	10.151819	10.087612	10.239431	49
12	9.760748	9.912299	9.848449	10.151551	10.087701	10.239252	48
13	9.760927	9.912210	9.848717	10.151283	10.087790	10 239073	47
14	9.761106	9.912121	9.848985	10.151015	10.087879	10.238894	46
15	9.761285	9.912031	9.849254	10.150746	10.087969	10.238715	45
16	9.761464	9.911942	9.849522	10.150478	10.088058	10.238536	44
17	9.761642	9.911853	9.849790	10.150210	10.088147	10.238358	43
18	9.761821	9.911763	9.850057	10.149943	10.088237	10.238179	42
19	9.761999	9.911674	9.850325	10.149675	10.088326	10.238001	41
20	9.762177	9.911584	9.850593	10.149407	10.088416	10.237823	40
21	9.762356	9.911495	9.850861	10.149139	10,088505	10.237644	39
22	9.762534	9.911405	9 851128	10.148872	10.088595	10.237466	38
23	9.762712	9.911315	9.851396	10.148604	10.088685	10.237288	37
24	9.762889	9.911226	9.851664	10.148336	10.088774	10.237111	36
25	9.763067	9.911136	9.851931	10.148069	10.088864	10.236933	35
26	9.763245	9.911046	9.852199	10.147801	10.088954	10.236755	34
27	9.763422	9.910956	9.852466	10.147534	10.089044	10.236578	33
28	9.763600	9.910866	9.852733	10.147267	10.089134	10.236400	32
29	9 763777	9.910776	9.853001	10.146999	10.089224	10.236223	31
30	9.763954	9.910686	9.853268	10.146732	10.089314	10.236046	30
		Sine		Tangent		Secant	Minutes

54 Degrees.

35 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.763954	9.910686	9.853268	10.146732	10.089314	10.236046	30
31	9.764131	9.910596	9.853535	10.146465	10.089404	10.235869	29
32	9.764308	9.910506	9.853802	10.146198	10.089494	10.235692	28
33	9.764485	9.910415	9.854069	10.145931	10.089585	10.235515	27
34	9.764662	9.910325	9.854336	10.145664	10.089675	10.235338	26
35	9.764838	9.910235	9.854603	10.145397	10.089765	10.235162	25
36	9.765015	9.910144	9.854870	10.145130	10.089856	10.234985	24
37	9.765191	9.910054	9.855137	10.144863	10.089946	10.234809	23
38	9.765367	9.909963	9.855404	10.144596	10.090037	10.234633	22
39	9.765544	9.909873	9.855671	10.144329	10.090127	10.234456	21
40	9.765720	9.909782	9.855938	10.144062	10.090218	10.234280	20
41	9.765896	9.909691	9.856204	10.143796	10.090309	10.234104	19
42	9.766071	9.909601	9.856471	10.143529	10.090399	10.233929	18
43	9.766247	9.909510	9.856737	10.143263	10.090490	10.233753	17
44	9.766423	9.909419	9.857004	10.142996	10.090581	10.233577	16
45	9.766598	9.909328	9.857270	10.142730	10.090672	10.233402	15
46	9.766774	9.909237	9.857537	10.142463	10.090763	10.233226	14
47	9.766949	9.909146	9.857803	10.142197	10.090854	10.233051	13
48	9.767124	9.909055	9.858069	10.141931	10.090945	10.232876	12
49	9.767300	9.908964	9.858336	10.141664	10.091036	10.232700	11
50	9.767475	9.908873	9.858602	10.141398	10.091127	10.232525	10
51	9.767649	9.908781	9.858868	10.141132	10.091219	10.232351	9
52	9.767824	9.908690	9.859134	10.140866	10.091310	10.232176	8
53	9.767999	9.908599	9.859400	10.140600	10.091401	10.232001	7
54	9.768173	9.908507	9.859666	10.140334	10.091493	10.231827	6
55	9.768348	9.908416	9.859932	10.140068	10.091584	10.231652	5
56	9.768522	9.908324	9.860198	10.139802	10.091676	10.231478	4
57	9.768697	9.908233	9.860464	10.139536	10.091767	10.231303	3
58	9.768871	9.908141	9.860730	10.139270	10.091859	10.231129	2
59	9.769045	9.908049	9.860995	10.139005	10.091951	10.230955	1
60	9.769219	9.907958	9.861261	10.138739	10.092042	10.230781	0
		Sine		Tangent		Secant	Minutes

54 Degrees.

36 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.769219	9.907958	9.861201	10.138739	10.092042	10.230781	60
1	9.769392	9.907866	9.861527	10.138473	10.092134	10.230608	59
2	9.769566	9.907774	9.861792	10.138208	10.092226	10.230434	58
3	9.769740	9.907682	9.862058	10.137942	10.092318	10.230260	57
4	9.769912	9.907590	9.862323	10.137677	10.092410	10.230088	56
5	9.770087	9.907498	9.862589	10.137411	10.092502	10.229913	55
6	9.770260	9.907406	9.862854	10.137146	10.092594	10.229740	54
7	9.770433	9.907314	9.863119	10.136881	10.092686	10.229567	53
8	9.770606	9.907222	9.863385	10.136615	10.092778	10.229394	52
9	9.770779	9.907129	9.863650	10.136350	10.092871	10.229221	51
10	9.770952	9.907037	9.863915	10.136085	10.092963	10.229048	50
11	9.771125	9.906945	9.864180	10.135820	10.093055	10.228875	49
12	9.771298	9.906852	9.864445	10.135555	10.093148	10.228702	48
13	9.771470	9.906760	9.864711	10.135289	10.093240	10.228530	47
14	9.771643	9.906667	9.864975	10.135025	10.093333	10.228357	46
15	9.771815	9.906574	9.865240	10.134760	10.093426	10.228185	45
16	9.771987	9.906482	9.865505	10.134495	10.093518	10.228013	44
17	9.772159	9.906389	9.865770	10.134230	10.093611	10.227841	43
18	9.772331	9.906296	9.866035	10.133965	10.093704	10.227669	42
19	9.772503	9.906204	9.866300	10.133700	10.093796	10.227497	41
20	9.772675	9.906111	9.866564	10.133436	10.093889	10.227325	40
21	9.772847	9.906018	9.866829	10.133171	10.093982	10.227153	39
22	9.773018	9.905925	9.867094	10.132906	10.094075	10.226982	38
23	9.773190	9.905832	9.867358	10.132642	10.094168	10.226810	37
24	9.773361	9.905739	9.867623	10.132377	10.094261	10.226639	36
25	9.773533	9.905645	9.867887	10.132113	10.094355	10.226467	35
26	9.773704	9.905552	9.868152	10.131848	10.094448	10.226296	34
27	9.773875	9.905459	9.868416	10.131584	10.094541	10.226125	33
28	9.774046	9.905366	9.868680	10.131320	10.094634	10.225954	32
29	9.774217	9.905272	9.868945	10.131055	10.094728	10.225783	31
30	9.774388	9.905179	9.869209	10.130791	10.094821	10.225612	30
		Sine		Tangent		Secant	Minutes

53 Degrees.

36 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.774388	9.905179	9.869209	10.130791	10.094821	10.225612	30
31	9.774558	9.905085	9.869473	10.130527	10.094915	10.225442	29
32	9.774729	9.904992	9.869737	10.130263	10.095008	10.225271	28
33	9.774899	9.904898	9.870001	10.129999	10.095102	10.225101	27
34	9.775070	9.904804	9.870265	10.129735	10.095196	10.224930	26
35	9.775240	9.904711	9.870529	10.129471	10.095289	10.224760	25
36	9.775410	9.904617	9.870793	10.129207	10.095383	10.224590	24
37	9.775580	9.904523	9.871057	10.128943	10.095477	10.224420	23
38	9.775750	9.904429	9.871321	10.128679	10.095571	10.224250	22
39	9.775920	9.904335	9.871585	10.128415	10.095665	10.224080	21
40	9.776090	9.904241	9.871849	10.128151	10.095759	10.223910	20
41	9.776259	9.904147	9.872112	10.127888	10.095853	10.223741	19
42	9.776429	9.904053	9.872376	10.127624	10.095947	10.223571	18
43	9.776598	9.903959	9.872640	10.127360	10.096041	10.223402	17
44	9.776768	9.903864	9.872903	10.127097	10.096136	10.223232	16
45	9.776937	9.903770	9.873167	10.126833	10.096230	10.223063	15
46	9.777106	9.903676	9.873430	10.126570	10.096324	10.222894	14
47	9.777275	9.903581	9.873694	10.126306	10.096419	10.222725	13
48	9.777444	9.903487	9.873957	10.126043	10.096513	10.222556	12
49	9.777613	9.903392	9.874220	10.125780	10.096608	10.222387	11
50	9.777781	9.903298	9.874484	10.125516	10.096702	10.222219	10
51	9.777950	9.903203	9.874747	10.125253	10.096797	10.222050	9
52	9.778119	9.903108	9.875010	10.124990	10.096892	10.221881	8
53	9.778287	9.903014	9.875273	10.124727	10.096986	10.221713	7
54	9.778455	9.902919	9.875536	10.124464	10.097081	10.221545	6
55	9.778623	9.902824	9.875800	10.124200	10.097176	10.221377	5
56	9.778792	9.902729	9.876063	10.123937	10.097271	10.221208	4
57	9.778960	9.902634	9.876326	10.123674	10.097366	10.221040	3
58	9.779128	9.902539	9.876589	10.123411	10.097461	10.220872	2
59	9.779295	9.902444	9.876851	10.123149	10.097556	10.220705	1
60	9.779463	9.902349	9.877114	10.122886	10.097651	10.220537	0
		Sine		Tangent		Secant	Minutes

53 Degrees.

37 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.779463	9.902349	9.877114	10.122886	10.097651	10.220537	60
1	9.779631	9.902253	9.877377	10.122623	10.097747	10.220369	59
2	9.779798	9.902158	9.877640	10.122360	10.097842	10.220202	58
3	9.779965	9.902063	9.877903	10.122097	10.097937	10.220035	57
4	9.780133	9.901967	9.878165	10.121835	10.098033	10 219867	56
5	9.780300	9.901872	9.878428	10.121572	10.098128	10.219700	55
6	9.780467	9.901776	9.878691	10.121309	10.098224	10.219533	54
7	9.780634	9.901681	9 878953	10.121047	10.098319	10.219366	53
8	9.780801	9.901585	9.879216	10.120784	10.098415	10.219199	32
9	9.780968	9.901489	9.879478	10.120522	10.098511	10.219032	51
10	9.781134	9.901394	9.879741	10.120259	10.098606	10.218866	50
11	9.781301	9.901298	9.880003	10.119997	10.098702	10.218699	49
12	9.781467	9.901202	9.880265	10.119735	10.098798	10.218533	48
13	9.781634	9.901106	9.880528	10.119472	10.098894	10.218366	47
14	9.781800	9.901010	9.880790	10.119210	10.098990	10.218200	46
15	9.781966	9.900914	9.881052	10.118948	10.099086	10.218034	45
16	9.782132	9.900818	9.881314	10.118686	10.099182	10.217868	44
17	9.782298	9.900722	9.881576	10.118424	10.099278	10.217702	43
18	9.782464	9.900626	9.881839	10.118161	10.099374	10.217536	42
19	9.782630	9.900529	9.882101	10.117899	10.099471	10.217370	41
20	9.782796	9.900433	9.882363	10.117637	10.099567	10.217204	40
21	9.782961	9.900337	9.882625	10.117375	10.099663	10.217039	39
22	9.783127	9.900240	9.882887	10.117113	10.099760	10.216873	38
23	9.783292	9.900144	9.883148	10.116852	10.099856	10.216708	37
24	9.783457	9.900047	9.883410	10.116590	10.099953	10.216543	36
25	9.783623	9.899951	9.883672	10.116328	10.100049	10.216377	35
26	9 783788	9.899854	9.883934	10.116066	10.100146	10.216212	34
27	9.783953	9.899757	9.884196	10.115804	10.100243	10.216047	33
28	9.784118	9.899660	9.884457	10.115543	10.100340	10.215882	32
29	9.784282	9.899564	9.884719	10.115281	10.100436	10.215718	31
30	9.784447	9.899467	9.884980	10.115020	10.100533	10.215553	30
		Sine		Tangent		Secant	Minutes

52 Degrees.

37 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.784447	9.899467	9.884980	10.115020	10.100533	10.215553	30
31	9.784612	9.899370	9.885242	10.114758	10.100630	10.215388	29
32	9.784776	9.899273	9.885503	10.114497	10.100727	10.215224	28
33	9.784944	9.899176	9.885765	10.114235	10.100824	10.215059	27
34	9.785105	9.899078	9.886026	10.113974	10.100922	10.214895	26
35	9.785269	9.898981	9.886288	10.113712	10.101019	10.214731	25
36	9.785433	9.898884	9.886549	10.113451	10.101116	10.214567	24
37	9.785597	9.898787	9.886810	10.113190	10.101213	10.214403	23
38	9.785761	9.898689	9.887072	10.112928	10.101311	10.214239	22
39	9.785925	9.898592	9.887333	10.112667	10.101408	10.214075	21
40	9.786089	9.898494	9.887594	10.112406	10.101506	10.213911	20
41	9.786252	9.898397	9.887855	10.112145	10.101603	10.213748	19
42	9.786416	9.898299	9.888116	10.111884	10.101701	10.213584	18
43	9.786579	9.898202	9.888377	10.111623	10.101798	10.213421	17
44	9.786742	9.898104	9.888639	10.111361	10.101896	10.213258	16
45	9.786906	9.898006	9.888900	10.111100	10.101994	10.213094	15
46	9.787069	9.897908	9.889160	10.110840	10.102092	10.212931	14
47	9.787232	9.897810	9.889421	10.110579	10.102190	10.212768	13
48	9.787395	9.897712	9.889682	10.110318	10.102288	10.212605	12
49	9.787557	9.897614	9.889943	10.110057	10.102386	10.212443	11
50	9.787720	9.897516	9.890204	10.109796	10.102484	10.212280	10
51	9.787883	9.897418	9.890465	10.109535	10.102582	10.212117	9
52	9.788045	9.897320	9.890725	10.109275	10.102680	10.211955	8
53	9.788208	9.897222	9.890986	10.109014	10.102778	10.211792	7
54	9.788370	9.897123	9.891247	10.108753	10.102877	10.211630	6
55	9.788532	9.897025	9.891507	10.108493	10.102975	10.211468	5
56	9.788694	9.896926	9.891768	10.108232	10.103074	10.211306	4
57	9.788856	9.896828	9.892028	10.107972	10.103172	10.211144	3
58	9.789018	9.896729	9.892289	10.107711	10.103271	10.210982	2
59	9.789180	9.896631	9.892549	10.107451	10.103369	10.210820	1
60	9.789342	9.896532	9.892810	10.107190	10.103468	10.210658	0
		Sine		Tangent		Secant	Minutes

52 Degrees.

38 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.789342	9.896532	9.892810	10.107190	10.103468	10.210658	60
1	9.789504	9.896433	9.893070	10.106930	10.103567	10.210496	59
2	9.789665	9.896335	9.893331	10.106669	10.103665	10.210335	58
3	9.789827	9.896236	9.893591	10.106409	10.103764	10.210173	57
4	9.789988	9.896137	9.893851	10.106149	10.103863	10.210012	56
5	9.790149	9.896038	9.894111	10.105889	10.103962	10.209851	55
6	9.790310	9.895939	9.894371	10.105629	10.104061	10.209690	54
7	9.790471	9.895840	9.894632	10.105368	10.104160	10.209529	53
8	9.790632	9.895741	9.894892	10.105108	10.104259	10.209368	52
9	9.790793	9.895641	9.895152	10.104848	10.104359	10 209207	51
10	9.790954	9.895542	9.895412	10.104588	10 104458	10.209046	50
11	9 791115	9.895443	9 895672	10.104328	10.104557	10.208885	49
12	9.791275	9.895343	9.895932	10.104068	10.104657	10.208725	48
13	9.791436	9.895244	9 896192	10.103808	10.104756	10.208564	47
14	9.791596	9.895144	9.896452	10.103548	10.104856	10.208404	46
15	9.791757	9.895045	9.896712	10.103288	10.104955	10.208243	45
16	9.791917	9.894945	9.896971	10.103029	10.105055	10.208083	44
17	9.792077	9.894846	9.897231	10.102769	10.105154	10.207923	43
18	9.792237	9.894746	9.897491	10.102509	10.105254	10.207763	42
19	9.792397	9.894646	9.897751	10.102249	10.105354	10.207603	41
20	9.792557	9.894546	9.898010	10.101990	10.105454	10.207443	40
21	9.792716	9.894446	9.898270	10.101730	10.105554	10.207284	39
22	9.792876	9 894346	9.898530	10.101470	10.105654	10.207124	38
23	9.793035	9.894246	9.898789	10.101211	10.105754	10.206965	37
24	9 793195	9.894146	9.899049	10.100951	10.105854	10.206805	36
25	9.793354	9.894046	9.899308	10.100692	10.105954	10.206646	35
26	9.793513	9.893946	9.899568	10.100432	10.106054	10.206487	34
27	9.793673	9 893846	9.899827	10.100173	10.106154	10.206327	33
28	9.793832	9.893745	9.900086	10.099914	10.106255	10.206168	32
29	9.793991	9.893645	9.900346	10.099654	10.106355	10.206009	31
30	9.794150	9.893544	9.900605	10.099395	10.106456	10.205850	30
		Sine		Tangent		Secant	Minutes

51 Degrees.

38 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.794150	9.893544	9.900605	10.099395	10.106456	10.205850	30
31	9.794308	9.893444	9.900864	10.099136	10.106556	10.205692	29
32	9.794467	9.893343	9.901124	10.098876	10.106657	10.205533	28
33	9.794626	9.893243	9.901383	10.098617	10.106757	10.205374	27
34	9.794784	9.893142	9.901642	10.098358	10.106858	10.205216	26
35	9.794942	9.893041	9.901901	10.098099	10.106959	10.205058	25
36	9.795101	9.892940	9.902160	10.097840	10.107060	10.204899	24
37	9.795259	9.892839	9.902419	10.097581	10.107161	10.204741	23
38	9.795417	9.892738	9.902679	10.097321	10.107262	10.204583	22
39	9.795575	9.892637	9.902938	10.097062	10.107363	10.204425	21
40	9.795733	9.892536	9.903197	10.096803	10.107464	10.204267	20
41	9.795891	9.892435	9.903455	10.096545	10.107565	10.204109	19
42	9.796049	9.892334	9.903714	10.096286	10.107666	10.203951	18
43	9.796206	9.892233	9.903973	10.096027	10.107767	10.203794	17
44	9.796364	9 892132	9.904232	10.095768	10.107868	10.203636	16
45	9.796521	9.892030	9.904491	10.095509	10.107970	10.203479	15
46	9.796679	9.891929	9.904750	10.095250	10.108071	10.203321	14
47	9.796836	9.891827	9.905008	10.094992	10.108173	10.203164	13
48	9.796993	9.891726	9.905267	10.094733	10.108274	10.203007	12
49	9.797150	9.891624	9.905526	10.094474	10.108376	10.202850	11
50	9.797307	9.891523	9.905784	10.094216	10.108477	10.202693	10
51	9.797464	9.891421	9.906043	10.093957	10.108579	10.202536	9
52	9.797621	9.891319	9.906302	10.093698	10.108681	10.202379	8
53	9.797777	9.891217	9.906560	10.093440	10.108783	10.202223	7
54	9.797934	9.891115	9.906819	10.093181	10.108885	10.202066	6
55	9.798091	9.891013	9 907077	10.092923	10.108987	10.201909	5
56	9.798247	9.890911	9.907336	10.092664	10.109089	10.201753	4
57	9.798403	9.890809	9.907594	10.092406	10.109191	10.201597	3
58	9.798560	9.890707	9.907852	10.092148	10.109293	10.201440	2
59	9.798716	9.890605	9.908111	10.091889	10.109395	10.201284	1
60	9.798872	9.890503	9.908369	10.091631	10.109497	10.201128	0
		Sine		Tangent		Secant	Minutes

51 Degrees.

39 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.798872	9.890503	9.908369	10.091631	10.109497	10.201128	60
1	9.799028	9.890400	9.908627	10.091373	10.109600	10 200972	59
2	9.799184	9.890298	9.908886	10.091114	10.109702	10.200816	58
3	9.799339	9.890195	9.909144	10.090856	10.109805	10.200661	57
4	9.799495	9.890093	9.909402	10.090598	10.109907	10 200505	56
5	9.799651	9.889990	9.909660	10.090340	10.110010	10.200349	55
6	9.799806	9.889888	9.909918	10.090082	10.110112	10.200194	54
7	9.799962	9 889785	9.910177	10.089823	10.110215	10.200038	53
8	9.800117	9.889682	9.910435	10.089565	10.110318	10.199883	32
9	9.800272	9.889579	9.910693	10.089307	10.110421	10.199728	51
10	9.800427	9.889476	9.910951	10.089049	10.110524	10.199573	50
11	9.800582	9.889374	9.911209	10.088791	10.110026	10.199418	49
12	9 800737	9.889271	9.911467	10.088533	10.110729	10.199263	48
13	9.800892	9.889167	9.911724	10.088276	10.110833	10.199108	47
14	9.801047	9 889064	9.911982	10.088018	10.110936	10.198953	46
15	9.801201	9.888961	9.912240	10.087760	10.111039	10.198799	45
16	9.801356	9.888858	9.912498	10.087502	10.111142	10.198644	44
17	9.801511	9.888755	9.912756	10.087244	10.111245	10.198489	43
18	9.801665	9.888651	9.913014	10.086986	10.111349	10.198335	42
19	9.801819	9.888548	9.913271	10.086729	10.111452	10.198181	41
20	9.801973	9.888444	9.913529	10.086471	10.111556	10.198027	40
21	9 802128	9.888341	9.913787	10.086213	10.111659	10.197872	39
22	9.802282	9.888237	9.914044	10.085956	10.111763	10.197718	38
23	9.802435	9.888133	9.914302	10.085698	10.111867	10.197565	37
24	9.802589	9.888030	9.914560	10.085440	10.111970	10.197411	36
25	9.802743	9.887926	9.914817	10.085183	10.112074	10.197257	35
26	9 802897	9.887822	9.915075	10.084925	10.112178	10 197103	34
27	9.803050	9.887718	9.915332	10.084668	10.112282	10.196950	33
28	9.803204	9.887614	9.915590	10.084410	10.112386	10.196796	32
29	9.803357	9.887510	9.915847	10.084153	10.112490	10.196643	31
30	9.803510	9.887406	9.916104	10.083896	10.112594	10.196490	30
		Sine		Tangent		Secant	Minutes

50 Degrees.

39 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.803510	9.887406	9.916104	10.083896	10.112594	10.196490	30
31	9.803664	9.887302	9.916362	10.083638	10.112698	10.196336	29
32	9 803817	9.887198	9.916619	10.083381	10.112802	10.196183	28
33	9.803970	9.887093	9.916876	10.083124	10.112907	10.196030	27
34	9.804123	9.886989	9.917134	10 082866	10.113011	10.195877	26
35	9.804276	9.886885	9.917391	10.082609	10.113115	10.195724	25
36	9.804428	9.886780	9.917648	10.082352	10.113220	10.195572	24
37	9.804581	9.886676	9.917905	10.082095	10.113324	10.195419	23
38	9.804734	9.886571	9.918163	10.081837	10.113429	10.195266	22
39	9.804886	9.886466	9.918420	10.081580	10.113534	10.195114	21
40	9.805038	9.886362	9.918677	10.081323	10.113638	10.194962	20
41	9.805191	9 886257	9.918934	10.081066	10.113743	10.194809	19
42	9.805343	9.886152	9.919191	10 080809	10.113848	10.194657	18
43	9 805495	9.886047	9.919448	10.080552	10.113953	10.194505	17
44	9.805647	9.885942	9.919705	10.080295	10.114058	10.194353	16
45	9.805799	9.885837	9.919962	10.080038	10.114163	10.194201	15
46	9.805951	9.885732	9.920219	10.079781	10.114268	10 194049	14
47	9.806103	9.885627	9.920476	10.079524	10.114373	10.193897	13
48	9 806254	9 885521	9.920733	10.079267	10.114479	10.193746	12
49	6.806406	9.885416	9.920990	10.079010	10.114584	10.193594	11
50	9.806557	9.885311	9.921247	10.078753	10.114689	10.193443	10
51	9.806709	9.885205	9.921503	10.078497	10.114795	10.193291	9
52	9.806860	9.885100	9 921760	10.078240	10.114900	10.193140	8
53	9.807011	9.884994	9.922017	10.077983	10.115006	10.192989	7
54	9.807163	9.884889	9.922274	10.077726	10.115111	10.192837	6
55	9.807314	9.884783	9.922530	10.077470	10.115217	10.192686	5
56	9.807465	9.884677	9.922787	10.077213	10.115323	10.192535	4
57	9.807615	9,884572	9.923044	10.076956	10.115428	10.192385	3
58	9.807766	9.884466	9.923300	10.076700	10 115534	10.192234	2
59	9.807917	9.884360	9.923557	10.076443	10.115640	10.192083	1
60	9 808067	9.884254	9.923813	10.076187	10.115746	10 191933	0
		Sine		Tangent		Secant	Minutes

50 Degrees.

40 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.808008	9.884254	9.923813	10.076187	10.115746	10.191932	60
1	9.808218	9.884148	9.924070	10.075930	10.115852	10.191782	59
2	9.808368	9.884042	9.924327	10.075673	10.115958	10.191632	58
3	9.808519	9.883936	9.924583	10.075417	10.116064	10.191481	57
4	9.808669	9.883829	9.924840	10.075160	10.116171	10.191331	56
5	9.808819	9.883723	9.925096	10.074904	10.116277	10.191181	55
6	9.808969	9.883617	9.925352	10.074648	10.116383	10.191031	54
7	9.809119	9 883510	9.925609	10.074391	10.116490	10.190881	53
8	9.809269	9.883404	9.925865	10.074135	10.116596	10.190731	32
9	9.809419	9.883297	9.926121	10.073879	10.116703	10.190581	51
10	9.809569	9.883191	9.926378	10.073622	10.116809	10.190431	50
11	9.809718	9.883084	9.926634	10.073366	10.116916	10.190282	49
12	9 809868	9.882977	9.926890	10.073110	10.117023	10.190132	48
13	9.810017	9.882871	9.927147	10.072853	10.117129	10.189983	47
14	9.810167	9 882764	9.927403	10.072597	10.117236	10.189833	46
15	9.810316	9.882657	9.927659	10.072341	10.117343	10.189684	45
16	9.810465	9.882550	9.927915	10.072085	10.117450	10.189535	44
17	9.810614	9.882443	9.928171	10.071829	10.117557	10.189386	43
18	9.810763	9.882336	9.928427	10.071573	10.117664	10.189237	42
19	9.810912	9.882228	9.928683	10.071317	10.117772	10.189088	41
20	9.811061	9.882121	9.928940	10.071060	10.117879	10.188939	40
21	9 811210	9 882014	9.929196	10.070804	10.117980	10.188790	39
22	9.811358	9.881907	9.929452	10.070548	10.118093	10.188642	38
23	9.811507	9.881799	9.929708	10.070292	10.118201	10.188493	37
24	9.811655	9.881692	9.929964	10.070036	10.118308	10.188345	36
25	9.811804	9.881584	9.930219	10.069781	10.118416	10.188196	35
26	9 811952	9.881477	9.930475	10.069525	10.118523	10.188048	34
27	9.812100	9.881369	9.930731	10.069269	10.118631	10.187900	33
28	9.812248	9.881261	9.930987	10.069013	10.118739	10.187752	32
29	9.812397	9.881153	9.931243	10.068757	10.118847	10.187603	31
30	9.812544	9.881045	9.931499	10.068501	10.118955	10.187456	30
		Sine		Tangent		Secant	Minutes

49 Degrees.

40 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.812544	9.881045	9.931499	10.068501	10.118955	10.187456	30
31	9.812692	9.880938	9.931755	10.068245	10.119062	10.187308	29
32	9 812840	9.880830	9.932010	10.067990	10.119170	10.187160	28
33	9.812988	9.880721	9.932266	10.067734	10.119279	10.187012	27
34	9.813135	9.880613	9.932522	10 067478	10.119387	10.186865	26
35	9.813283	9.880505	9.932778	10.067222	10.119495	10.186717	25
36	9.813430	9.880397	9.933033	10.066967	10.119603	10.186570	24
37	9.813578	9.880289	9.933289	10.066711	10.119711	10.186422	23
38	9.813725	9.880180	9.933545	10.066455	10.119820	10.186275	22
39	9.813872	9.880072	9.933800	10.066200	10.119928	10.186128	21
40	9.814019	9.879963	9.934056	10.065944	10.120037	10.185981	20
41	9.814166	9.879855	9.934311	10.065689	10.120145	10.185834	19
42	9.814313	9.879746	9.934567	10 065433	10.120254	10.185687	18
43	9 814460	9.879637	9.934823	10.065177	10.120363	10.185540	17
44	9.814607	9.879529	9.935078	10.064922	10.120471	10.185393	16
45	9.814753	9.879420	9.935333	10.064667	10.120580	10.185247	15
46	9.814900	9.879311	9.935589	10.064411	10.120689	10.185100	14
47	9.815046	9.879202	9.935844	10.064156	10.120798	10.184954	13
48	9 815193	9.879093	9.936100	10.063900	10.120907	10.184807	12
49	9.815339	9.878984	9.936355	10.063645	10.121016	10.184661	11
50	9.815485	9.878875	9.936610	10.063390	10.121125	10.184515	10
51	9.815631	9.878766	9.936866	10.063134	10.121234	10.184369	9
52	9.815778	9.878656	9.937121	10.062879	10.121344	10.184222	8
53	9.815923	9.878547	9.937376	10.062624	10.121453	10.184077	7
54	9.816069	9.878438	9.937632	10.062368	10.121562	10.183931	6
55	9.816215	9.878328	9.937887	10.062113	10.121672	10.183785	5
56	9.816361	9.878219	9.938142	10.061858	10.121781	10.183639	4
57	9.816507	9.878109	9.938397	10.061603	10.121891	10.183493	3
58	9.816652	9.877999	9.938653	10.061347	10.122001	10.183348	2
59	9.816797	9.877890	9.938908	10.061092	10.122110	10.183203	1
60	9 816943	9.877780	9.939163	10.060837	10.122220	10 183057	0
		Sine		Tangent		Secant	Minutes

49 Degrees.

41 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.816943	9.877780	9.939163	10.060837	10.122220	10.183057	60
1	9.817088	9.877670	9.939418	10.060582	10.122330	10.182912	59
2	9.817233	9.877560	9.939673	10.060327	10.122440	10.182767	58
3	9.817378	9.877450	9.939928	10.060072	10.122550	10.182622	57
4	9.817523	9.877340	9.940183	10.059817	10.122660	10.182477	56
5	9 817668	9.877230	9.940438	10.059562	10.122770	10.182332	55
6	9 817813	9.877120	9.940694	10.059306	10.122880	10.182187	54
7	9.817958	9.877010	9.940949	10.059051	10.122990	10.182042	53
8	9.818103	9.876899	9.941204	10.058796	10.123101	10.181897	52
9	9.818247	9.876789	9 941458	10.058542	10.123211	10.181753	51
10	9.818392	9.876678	9.941713	10.058287	10 123322	10.181608	50
11	9.818536	9.876568	9.941968	10.058032	10.123432	10.181464	49
12	9.818681	9.876457	9.942223	10.057777	10.123543	10.181319	48
13	9.818825	9.876347	9.942478	10.057522	10.123653	10.181175	47
14	9.818969	9 876236	9.942733	10.057267	10.123764	10.181031	46
15	9.819113	9.876125	9 942988	10.057012	10.123875	10.180887	45
16	9.819257	9.876014	9.943243	10.056757	10.123986	10.180743	44
17	9.819401	9.875904	9.943498	10.056502	10.124096	10.180599	43
18	9.819545	9.875793	9.943752	10.056248	10.124207	10.180455	42
19	9.819689	9.875682	9.944007	10.055993	10 124318	10.180311	41
20	9.819832	9.875571	9.944262	10.055738	10.124429	10.180168	40
21	9.819976	9.875459	9.944517	10.055483	10.124541	10.180024	39
22	9.820120	9.875348	9 944771	10.055229	10.124652	10.179880	38
23	9.820263	9.875237	9.945026	10.054974	10.124763	10.179737	37
24	9.820406	9.875126	9.945281	10.054719	10.124874	10.179594	36
25	9.820550	9.875014	9.945535	10.054465	10 124986	10.179450	35
26	9.820693	9.874903	9.945790	10.054210	10.125097	10.179307	34
27	9.820836	9.874791	9.946045	10.053955	10,125209	10.179164	33
28	9.820979	9.874679	9.946299	10.053701	10.125321	10.179021	32
29	9.821122	9.874568	9.946554	10.053446	10.125432	10.178878	31
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735	30
		Sine		Tangent		Secant	Minutes

48 Degrees.

41 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.821265	9.874456	9.946808	10.053192	10.125544	10.178735	30
31	9.821407	9.874344	9.947063	10.052937	10.125656	10.178593	29
32	9.821550	9.874232	9.947317	10.052683	10.125768	10.178450	28
33	9.821693	9.874120	9.947572	10.052428	10.125880	10.178307	27
34	9.821835	9.874008	9.947826	10.052174	10.125992	10.178165	26
35	9.821977	9.873896	9.948081	10.051919	10.126104	10.178023	25
36	9.822120	9.873784	9.948335	10.051665	10.126216	10.177880	24
37	9.822262	9.873672	9.948590	10.051410	10.126328	10.177738	23
38	9.822404	9.873560	9.948844	10.051156	10.126440	10.177596	22
39	9.822546	9.873448	9.949099	10.050901	10.126552	10.177454	21
40	9.822688	9.873335	9.949353	10.050047	10.126665	10.177312	20
41	9.822830	9.873223	9.949607	10.050393	10.126777	10.177170	19
42	9.822972	9.873110	9.949862	10.050138	10.126890	10.177028	18
43	9.823114	9.872998	9.950116	10.049884	10.127002	10.176886	17
44	9.823255	9.872885	9.950370	10.049630	10.127115	10.176745	16
45	9.823397	9.872772	9.950625	10.049375	10.127228	10.176603	15
46	9.823539	9.872659	9.950879	10.049121	10.127341	10.176461	14
47	9.823680	9.872547	9.951133	10.048867	10.127453	10.176320	13
48	9.823821	9.872434	9.951388	10.048612	10.127566	10.176179	12
49	9.823963	9.872321	9.951642	10.048358	10.127679	10.176037	11
50	9.824104	9.872208	9.951896	10.048104	10.127792	10.175896	10
51	9.824245	9.872094	9.952150	10.047850	10.127906	10.175755	9
52	9.824386	9.871981	9.952404	10.047596	10.128019	10.175614	8
53	9.824527	9.871868	9.952659	10.047341	10.128132	10.175473	7
54	9.824668	9.871755	9.952913	10.047087	10.128245	10.175332	6
55	9.824808	9.871641	9.953167	10.046833	10.128359	10.175192	5
56	9.824949	9.871528	9.953421	10.046579	10.128472	10.175051	4
57	9.825090	9.871414	9.953675	10.046325	10.128586	10.174910	3
58	9.825230	9.871301	9.953929	10.046071	10.128699	10.174770	2
59	9.825370	9.871187	9.954183	10.045817	10.128813	10.174630	1
60	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489	0
		Sine		Tangent		Secant	Minutes

48 Degrees.

42 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.825511	9.871073	9.954437	10.045563	10.128927	10.174489	60
1	9.825651	9.870960	9.954691	10.045309	10.129040	10.174349	59
2	9.825791	9.870846	9.954945	10.045055	10.129154	10.174209	58
3	9.825931	9.870732	9.955199	10.044801	10.129268	10.174069	57
4	9.826071	9.870618	9.955453	10.044547	10.129382	10.173929	56
5	9.826211	9.870504	9.955707	10.044293	10.129496	10.173789	55
6	9.826351	9.870390	9.955961	10.044039	10.129610	10.173649	54
7	9.826491	9.870276	9.956215	10.043785	10.129724	10.173509	53
8	9.826631	9.870161	9.956469	10.043531	10.129839	10.173369	52
9	9.826770	9.870047	9.956723	10.043277	10.129953	10.173230	51
10	9.826910	9.869933	9.956977	10.043023	10 130067	10.173090	50
11	9.827049	9.869818	9.957231	10.042769	10.130182	10.172951	49
12	9.827189	9.869704	9.957485	10.042515	10.130296	10.172811	48
13	9.827328	9.869589	9.957739	10.042261	10.130411	10.172672	47
14	9.827467	9 869474	9.957993	10.042007	10.130526	10.172533	46
15	9.827606	9.869360	9.958246	10.041754	10.130640	10.172394	45
16	9.827745	9.869245	9.958500	10.041500	10.130755	10.172255	44
17	9.827884	9.869130	9.958754	10.041246	10.130870	10.172116	43
18	9.828023	9.869015	9.959008	10.040992	10.130985	10.171977	42
19	9.828162	9.868900	9.959262	10.040738	10.131100	10.171838	41
20	9.828301	9.868785	9.959515	10.040485	10.131215	10.171699	40
21	9.828439	9.868670	9.959769	10.040231	10.131330	10.171561	39
22	9.828578	9.868555	9 960023	10.039977	10.131445	10.171422	38
23	9.828716	9.868440	9.960277	10.039723	10.131560	10.171284	37
24	9.828855	9.868324	9.960530	10.039470	10.131676	10.171145	36
25	9.828993	9.868209	9.960784	10.039216	10 131791	10.171007	35
26	9.829131	9.868093	9.961038	10.038962	10.131907	10.170869	34
27	9.829269	9.867978	9.961291	10.038709	10.132022	10.170731	33
28	9.829407	9.867862	9.961545	10.038455	10.132138	10.170593	32
29	9.829545	9.867747	9.961799	10 038201	10.132253	10.170455	31
30	9.829683	9.867631	9.962052	10.037948	10.132369	10.170317	30
		Sine		Tangent		Secant	Minutes

47 Degrees.

42 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.829683	9.867631	9.962052	10.037948	10.132369	10.170317	30
31	9.829821	9.867515	9.962306	10.037694	10 132485	10.170179	29
32	9.829959	9.867399	9.962560	10.037440	10.132601	10.170041	28
33	9.830097	9.867283	9.962813	10.037187	10.132717	10.169903	27
34	9.830234	9.867167	9 963067	10.036933	10.132833	10.169766	26
35	9.830372	9 867051	9.963320	10.036680	10 132949	10.169628	25
36	9.830509	9.866935	9.963574	10.036426	10.133065	10.169491	24
37	9.830646	9.866819	9.963827	10.036173	10.133181	10.169354	23
38	9.830784	9.866703	9.964081	10.035919	10.133297	10.169216	22
39	9.830921	9.866586	9 964335	10.035665	10.133414	10.169079	21
40	9.831058	9 866470	9.964588	10.035412	10.133530	10.168942	20
41	9.831195	9.866353	9.964842	10.035158	10.133647	10.168805	19
42	9.831332	9.866237	9.965095	10.034905	10.133763	10.168668	18
43	9.831469	9.866120	9.965349	10.034651	10.133880	10.168531	17
44	9.831606	9.866004	9.965602	10.034398	10.133996	10.168394	16
45	9.831742	9.865887	9.965855	10.034145	10.134113	10.168258	15
46	9.831879	9.865770	9.966109	10.033891	10.134230	10.168121	14
47	9.332015	9.865653	9.966362	10.033638	10.134347	10.167985	13
48	9.832152	9.865536	9.966616	10.033384	10.134464	10.167848	12
49	9.832288	9.865419	9.966869	10 033131	10 134581	10.167712	11
50	9 832425	9.865302	9.967122	10.032878	10.134698	10.167575	10
51	9.832561	9.865185	9.967376	10.032624	10.134815	10.167439	9
52	9.832697	9.865068	9.967630	10.032370	10.134932	10.167303	8
53	9 832833	9.864950	9.967883	10.032117	10.135050	10.167167	7
54	9.832969	9.864833	9.968136	10.031864	10.135167	10.167031	6
55	9.833105	9.864716	9.968389	10.031611	10 135284	10.166895	5
56	9.833241	9.864598	9 968643	10.031357	10.135402	10.166759	4
57	9.833377	9.864481	9.968896	10.031104	10 135519	10.166623	3
58	9.833512	9.864363	9.969149	10.030851	10 135637	10.166488	2
59	9.833648	9.864245	9.969403	10.030597	10.135755	10.166352	1
60	9.833783	9.864127	9.969656	10.030344	10.135873	10 166217	0
		Sine		Tangent		Secant	Minute

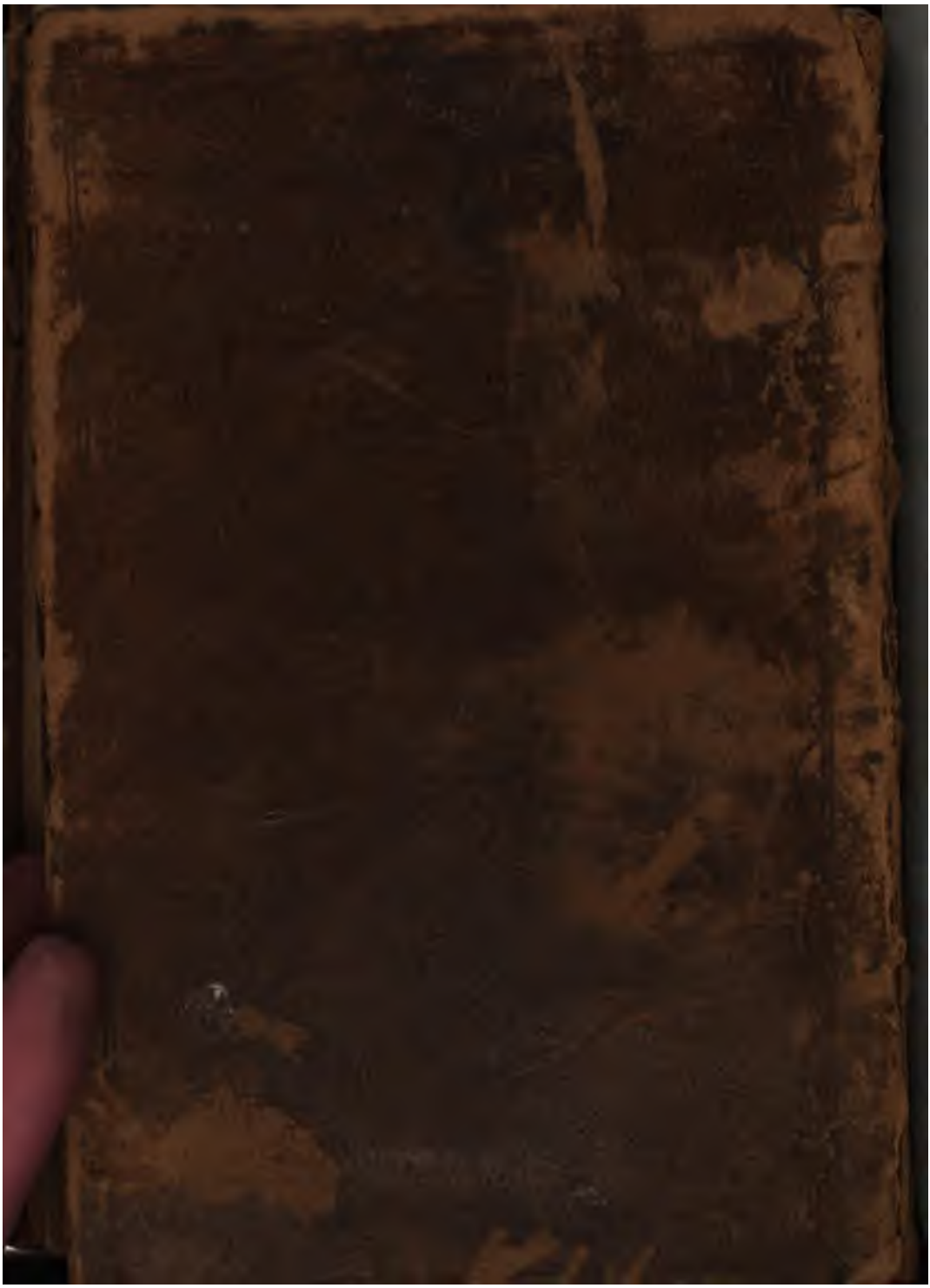
47 Degrees.

43 Degrees.

Minutes	Sine		Tangent		Secant		
0	9.833783	9.864127	9.969656	10 030344	10.135873	10.166217	60
1	9.833919	9.864010	9.969909	10.030091	10.135990	10.166081	59
2	9.834054	9.863892	9.970162	10.029838	10.136108	10.165946	58
3	9.834189	9.863774	9.970416	10.029584	10.136226	10.165811	57
4	9.834325	9.863656	9.970669	10.029331	10.136344	10.165675	56
5	9.834460	9.863538	9.970922	10.029078	10.136462	10.165540	55
6	9.834595	9.863419	9.971175	10.028825	10.136581	10.165405	54
7	9.834730	9.863301	9.971429	10.028571	10.136699	10.165270	53
8	9.834865	9.863183	9.971682	10.028318	10.136817	10.165135	52
9	9.834999	9.863064	9.971935	10.028065	10.136936	10.165001	51
10	9.835134	9.862946	9.972188	10.027812	10.137054	10.164866	50
11	9.835269	9.862827	9.972441	10.027559	10.137173	10.164731	49
12	9.835403	9.862709	9.972695	10.027305	10.137291	10.164597	48
13	9.835538	9.862590	9.972948	10.027052	10.137410	10.164462	47
14	9.835672	9.862471	9.973201	10.026799	10.137529	10.164328	46
15	9.835807	9.862353	9.973454	10.026546	10.137647	10.164193	45
16	9.835941	9.862234	9.973707	10.026293	10.137766	10.164059	44
17	9.836075	9.862115	9.973960	10.026040	10.137885	10.163925	43
18	9.836209	9.861996	9.974213	10.025787	10.138004	10.163791	42
19	9.836343	9.861877	9.974466	10.025534	10.138123	10.163657	41
20	9.836477	9.861758	9.974719	10.025281	10.138242	10.163523	40
21	9.836611	9.861638	9.974973	10.025027	10.138362	10.163389	39
22	9.836745	9.861519	9.975226	10.024774	10.138481	10.163255	38
23	9.836878	9.861400	9.975479	10.024521	10.138600	10 163122	37
24	9.837012	9.861280	9.975732	10.024268	10.138720	10.162988	36
25	9.837146	9.861161	9.975985	10.024015	10.138839	10.162854	35
26	9.837279	9.861041	9.976238	10.023762	10.138959	10.162721	34
27	9.837413	9.860921	9.976491	10.023509	10.139079	10.162587	33
28	9.837546	9.860802	9.976744	10 023256	10.139198	10.162454	32
29	9 837679	9.860682	9.976997	10.023003	10.139318	10.162321	31
30	9.837812	9.860562	9.977250	10.022750	10 139438	10.162188	30
		Sine		Tangent		Secant	Minutes

46 Degrees.

43 Degrees.

Minutes	Sine		Tangent		Secant		
30	9.837812	9.860562	9.977250	10.022750	10.139438	10.162188	30
31	9.837945	9.860442	9.977503	10.022497	10.139558	10.162055	29
32	9.838078	9.860322	9.977756	10.022244	10.139678	10.161922	28
33	9.838211	9.860202	9.978009	10.021991	10.139798	10.161789	27
34	9.838344	9.860082	9.978262	10.021738	10.139918	10.161656	26
35	9.838477	9.859962	9.978515	10.021485	10.140038	10.161523	25
36	9.838610	9.859842	9.978768	10.021232	10.140158	10.161390	24
37	9.838742	9.859721	9.979021	10.020979	10.140279	10.161258	23
38	9.838875	9.859601	9.979274	10.020726	10.140399	10.161125	22
39	9.839008	9.859480	9.979527	10.020473	10.140520	10.160993	21
40	9.839140	9.859360	9.979780	10.020220	10.140640	10.160860	20
41	9.839272	9.859239	9.980033	10.019967	10.140761	10.160728	19
42	9.839404	9.859119	9.980286	10.019714	10.140881	10.160596	18
43	9.839536	9.858998	9.980538	10.019462	10.141002	10.160464	17
44	9.839668	9.858877	9.980791	10.019209	10.141123	10.160332	16
45	9.839800	9.858756	9.981044	10.018956	10.141244	10.160200	15
46	9.839932	9.858635	9.981297	10.018703	10.141365	10.160068	14
47	9.840064	9.858514	9.981550	10.018450	10.141486	10.159936	13
48	9.840196	9.858393	9.981803	10.018197	10.141607	10.159804	12
49	9.840328	9.858272	9.982056	10.017944	10.141728	10.159672	11
50	9.840459	9.858150	9.982309	10.017691	10.141850	10.159541	10
51	9.840591	9.858029	9.982562	10.017438	10.141971	10.159409	9
52	9.840722	9.857908	9.982814	10.017186	10.142092	10.159278	8
53	9.840854	9.857786	9.983067	10.016933	10.142214	10.159146	7
54	9.840985	9.857665	9.983320	10.016680	10.142335	10.159015	6
55	9.841116	9.857543	9.983573	10.016427	10.142457	10.158884	5
56	9.841247	9.857421	9.983826	10.016174	10.142579	10.158753	4
57	9.841378	9.857300	9.984079	10.015921	10.142700	10.158622	3
58	9.841509	9.857178	9.984331	10.015669	10.142822	10.158491	2
59	9.841640	9.857056	9.984584	10.015416	10.142944	10.158360	1
60	9.841771	9.856934	9.984837	10.015163	10.143066	10.158229	0
		Sine		Tangent		Secant	Minutes

46 Degrees.